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Economic Impact and Obstacles to Mainstream Biodiesel Integration

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Abstract: Active research is being conducted to enable the integration of an alternate energy sources so as to replace petroleum based fuels. However, this research has been confined primarily within the auspices of a research laboratory. Of the various alternate energy source available today, biodiesel constitutes perhaps the most dominant and promising alternate energy source. A comprehensive analysis of the processes and effects involved with its integration would need to be conducted before said transition could occur as efficiently and as seamlessly as possible. These processes can recognize the mass appeal of biodiesel and its viability as a dominant energy source. This information can be used to develop a comprehensive methodology to achieve large-scale transfer of technology from the laboratory to the marketplace. Such a methodology needs to take into account the technological characteristics of the fuel production process, environmental effects of biodiesel emissions, and economic factors integral to the biodiesel supply chain. It is essential to analyze the characteristics and effects of this integration in order to successfully achieve the cost effective integration of this alternate fuel source into the marketplace. The aforementioned analysis would serve as a stepping stone or a foundation block to enable future research. This paper presents an overview of current practices and state of the art research focusing on integration of biodiesel into a mainstream marketplace.

Keywords: Renewable Energy, Bio-diesel, Clean Energy, Economic Analysis.

1. Introduction

Energy is the driving force of human civilization. The exponential rise in productivity and higher standard of living since the industrial revolution has been made possible by incremental innovations in technology. Our current way of life has spawned innovations in products and services that tend to consume significant amounts of energy. Fossil fuels have traditionally been the principal energy source globally since the dawn of the industrial revolution. They can be classified into three types, based on their physical characteristics. Crude oil, natural gas, and coal constitute the three conventional forms of fossil fuels (Whitney et al, 2009). Controlled combustion of fossil fuels results in the release of heat. Heat can be further harnessed to provide different forms of energy. Global supply of fossil fuels is limited. There has been growing evidence that points to decreasing supplies of coal as well as crude oil over the past three decades. For instance the peak oil theory propounded in the 1970's predicted that global oil reserves had already reached their maximum capacity and would begin a gradual but definite decline in the years ahead (Tyson, 1997). This is not a theory anymore. Its authenticity has been verified by the astronomical rise in gas prices that occurred in 2008. Price of any commodity is a function of supply and demand. Price will tend to rise in the face of adverse supply condition even if the demand for such commodity is flat. This fact applies equally well to the prices of coal and natural gases. For instance, according to the World Coal Institute, of all the coal that has been mined historically 80% has been mined in the last 60 years (World Coal Institute, 2011).

The demand dynamic spells a dire need for additional feasible energy sources since the global demand for energy has been steadily increasing due to the rising standards of living of peoples across the world. Thus, a substantial investment in energy and energy production and distribution infrastructure is essential in order to meet this demand. Hence, it is not only important to tap more efficient ways of power generation and distribution but a greater emphasis on exploiting non-conventional sources of energy such as solar power, wind power, hydroelectric power, tidal power, nuclear power, and bio-fuels is essential as well. The production statistics for alternate energy in the United States leave a lot to be desired in terms of mainstream market penetration. For instance, according to the Renewable Energy Research Lab, wind power constitutes approximately only about 6% of all power generated in the United States per year (Renewable energy research lab, UMASS, 2008). This is just one example of the miniscule representation of alternate energy sources in the conventional energy market. There is definite potential for the mainstream development of various alternate and their large-scale introduction, integration, and implementation could provide outstanding opportunities for growth for different entities including individuals, companies, and

organizations. Renewable energy sources are advantageous to the consumer in a variety of ways. Energy sources such as solar power, wind power, hydroelectric power, and bio-fuels can easily be replaced and remanufactured. Most of the alternative energy sources are also highly environmentally friendly compared to fossil fuels. The need to reduce the dependence on fossil fuels has increased dramatically. The necessary technologies and opportunities to significantly reduce the dependence on crude oil and other fossil fuels exist however, they have not been implemented fully (Fripp *et al*, 2004).

Bio-fuels lend themselves most readily to widespread adoption. This is due to the fact that they are easily adaptable to the current state of technology. The origin of bio-fuels can be traced to plants and animal fat. Plants use photosynthesis to create food for growth and to produce biomass. This is also referred to as bio-matter and is used to produce bio-fuels. Bio-fuels can be obtained in a liquid, solid, or gaseous form. Liquid bio-fuels however are the most widely and commonly available. They can be comprised of alcohol from fermenting sugars in plants, and this would be a bio-ethanol. Bio-fuels can also be created from vegetable oils, animal fats, and recycled grease composites; this is called bio-diesel. Last year bio-fuels provided almost 2% of the world's transport fuel (Vasudevan, 2008). With the rise in prices of fossil fuels rise and companies' increased interested in their biological footprint this number is expected to increase. Bio-diesel can be readily used to replace and or accompany gasoline as a primary fuel source for internal combustion engines. Bio-diesel has a distinct benefit over most other bio-fuels; it requires little to no conversion for use. Bio-diesel fuels will combust in a standard diesel engine without any modification. It can also be combined with petro-diesel for optimum effects. The reaction with bio-diesel that causes erosion and degradation of rubber lines, seals, and hoses in older cars is the only cause for concern. However, this is easily overcome by replacing these elements with a sustainable material such as fluoroelastomers (FCM), which are nonreactive to bio-diesel (Van Gerpen, 2004). There are also many types of bio-diesel; bio-diesel can be produced from a lot of different types of vegetables oils. The most common bio-diesel is from chemically reacting lipids.

Given their importance as detailed in the preceding paragraph, this paper explores research in bio-fuel production, commercialization methodologies, and economical advantages of their large-scale adoption. It is an ongoing topic of research and development that must be sub-divided into many subprojects and research endeavors. This is the first step towards development of a comprehensive methodology that could effectively transfer bio-diesel technology from the laboratory to the market place and it is just as important as the technological development if not more. This methodology could be developed and gauged by the amount of time required for a technology to become marketable as well as its related cost. Also, long-term acceptance by the market and the actual availability to the consumer can be measured (Van Gerpen, 2004). There has been significant interest in renewable energy and its applications in recent years. This is primarily attributable to the dwindling supply of fossil fuels as a dominant energy source and the subsequent astronomical rise in gas prices.

2. Reason for Mainstream Integration of Biodiesel

The following section describes the rationale for bio-diesel integration and how these concepts contribute to the economy, environment, and everyday human life present and future. The advancement of human civilization depends on the development of technology. Having a stable power source that can manage the increasing need for more energy is a root issue in developing such a technology based infrastructure. The following conditions are factors that contribute to the overall need for an alternative energy source that could replace fossil fuels.

2.1. Increase in Gas Prices

The fluctuation in gas prices as shown below in Figure 1creates an unstable economy because of the evident correlation in general market prices and gas prices. As prices increasingly fluctuate they affect the cost of transport and the consumptions of goods and service by consumers. As oil prices increase its effects trickles down through the entire economy. When there are large reserves and a relative increase in the number of active drilling sites with respect to oil, the economy temporarily improves. This creates more supply and prices fall, therefore people save money on gas and can consume other items in the economy. People working in these industries have more job openings and more jobs are filled, therefore creating a lower unemployment rate and a higher national per capita income. This process explains how fuel prices affect the wellness of our economy. The evident rise in fossil fuels prices will reach a point where any alternative fuel source will be cheaper and more feasible due to its diminishing supply.

2.2. Economic Effects of Fossil Fuels based Energy

The evident direct effect of the primary fuel source demonstrates an immense significance to the wellbeing of the economy, but the indirect effects are even more significant. Referring to (Table 1). If the cost of bread is $1.00, given the total cost of production for this loaf of bread $0.60, transportation cost $0.07 per loaf, stocking fee $0.02 per loaf, miscellaneous $0.01 per loaf, giving the dealer cost for a loaf of bread to $0.70 per loaf. For each loaf the consumer buys, the retailer makes 30% profit before the average damaged good is calculated, thus brings us to 25% profit per loaf. Referring to figure 1, the fluctuation in gas prices on November 19, 2009 where gas prices were $1.43 to June 29, 2008 when the price of gas per gallon had increased to $4.12 which is a 188% increase in price. Applying that to the theoretic bread scenario, it would push the cost of transport to $0.20. The difference of $0.13 per loaf is 50% of the retailer's profit, so an apparent price adjustment would have to be made.

Table 1. Indirect effect of change in gas prices on pricing of consumer goods.

Price of Gas	**$ 1.43**	**$ 4.12**
Production	$ 0.60	$ 0.60
Transportation	**$ 0.07**	**$ 0.20**
Stocking Fee	$ 0.02	$ 0.02
Miscellaneous	$ 0.01	$ 0.01
Total Cost	$ 0.70	**$ 0.83**
Retail	$ 1.00	$ 1.00
Profit	$ 0.30	$ 0.17

This scenario has the same effect on all consumed products. In reality they may not be as dramatic. This creates the inverse of the aforementioned scenario such that, people are able to consume fewer products at a higher price. There is less supply and prices rise even more, people spend more money on gas and can't consume other items in the economy as easily. People working in these industries have less employment opportunities, therefore creating a higher unemployment rate and a lower national per capita income.

The reliance on such an oscillating market is bound for disaster and detrimental situations that are unavoidable. The integration of such a product that would offer a sustainable and reliant price point could open doors to a more grounded and sustainable economy. Bio-diesel offers the solid infrastructure that could make this a reality. The cost of transportation is lower because it can be grown locally and produced by such a wide variety of goods. The opportunity to create localized market based on the local energy consumption could stimulate the area's economy. Lastly with such a wide variety of sources for bio-fuel, it offer a rich yield that can be converted to energy. With such positive resulting factors involving the integration of bio-fuels versus the apparent economic unstable position of fossil fuels, it is evident that bio-fuels are the best choice to power our growing economy.

Figure 1. 6 year chart showing the upward unsteady rise in petroleum gasoline prices (Gas Buddy, 2011).

2.3. Environmental Effects of Fossil Fuels

Fossil fuels have detrimental effects on the environment. This phenomenon is observed during the lifecycle of a fossil fuel: beginning with its extraction and ending with emission into the atmosphere. The effects of these harmful toxins are often very indirect, unnoticeable and sometimes long-term and irreversible. These toxins can cause damage to land from coal mining and damage to miners from black lung disease; environmental degradation caused by global warming, acid rain, and water pollution; and national security costs, such as protecting foreign sources of oil. Many of the prevalent environmental problems today result from our fossil fuel dependence.

- Thermal, Air, Water, and Land Pollution

Production, transportation, and use of oil can cause water pollution. Oil spills, for example, leave waterways and their surrounding shores uninhabitable for some time. Such spills often result in the loss of plant and animal life. Coal contains pyrite, a sulfur compound; as water washes through mines, this compound forms a dilute acid, which is then washed into nearby rivers and streams. Fossil fuels also contaminate the air and water. Several important pollutants are produced by fossil fuel combustion: carbon monoxide, nitrogen oxides, sulfur oxides, and hydrocarbons. During the process of generating electricity, fossil fuels produce heat energy, since the process is inefficient, much of the heat is released to the atmosphere or to water that is used as a coolant. The heated water then returns to rivers or lakes and can upset the aquatic ecosystem.

- Global Warming

Global warming is the increase of global temperature caused by the impact of human civilization. It is often a topic that is debatable among different people but the facts show that the slow and gradual accumulation of greenhouse gases causes the greenhouse effect. This happens when “greenhouse gases” prevent the release of heat from the earth’s atmosphere. The concept is simple. A greenhouse allows heat to enter but prevents most of it from exiting. The greenhouse gasses act as the greenhouse and trap the suns heat and radiation within our atmosphere. Greenhouse gasses absorb the radiation from the sun and hold the heat in the atmosphere and cause the air temperature to increase. This process can lead to global warming, which could trigger many different negative environmental effects that could have destructive reactions to our planet. Based their percentage contribution to the greenhouse effect, the four major greenhouse gases are (NCEP, 2010):

- Water vapor, 36–70%
- Carbon dioxide, 9–26%
- Methane, 4–9%
- Ozone, 3–7%

The increase of the greenhouse effect through human activities is known as the anthropogenic effect. This increase in greenhouse gasses from human activity is attributable mainly to increased atmospheric carbon dioxide levels. Carbon dioxide is produced by fossil fuel burning and other activities such as cement production and tropical deforestation. As we industrialize more and do not take this pollution into account it will only get worse. Our atmosphere will continue to become polluted and the effects of global warming will continue to increase.This concept has been questioned since the idea was presented because of the massive size of the atmosphere, and how unlikely that humans could produce enough pollution to alter how the atmosphere works. Countless evidence shows that humans produce excessive amounts of CO_2 to an extent that would increase the greenhouse effect. Measurements of CO_2 from the Mauna Loa observatory show that concentrations have increased from about 313 parts per million (ppm) in 1960 to about 389 ppm in 2010 (Rhodes, 2009). The current observed amount of CO_2 exceeds the geological record maxima of about 300 ppm from ice core data. So given the inexcusable evidence it would be implausible to state that the effects of pollution are not contributable to global warming due to greenhouse gasses absorbing and not releasing heat and radiation.

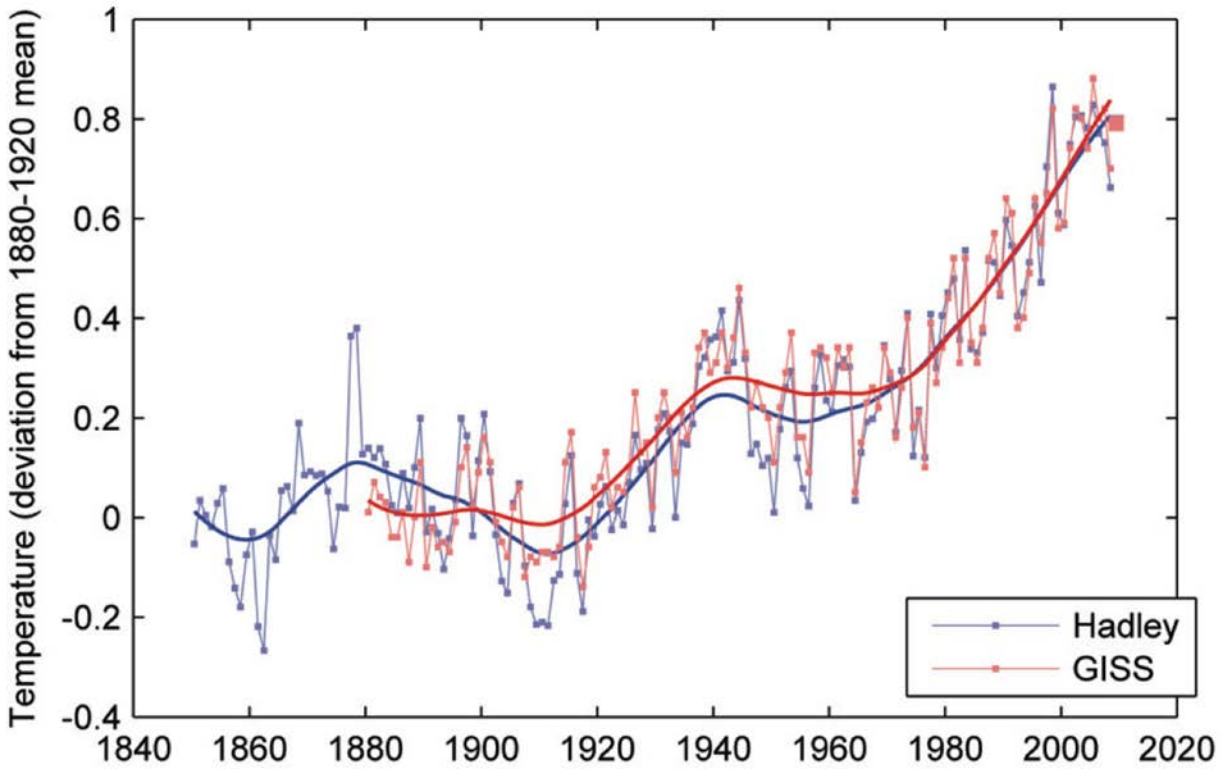

Figure 2. The evident rise in the global temperature over the last 80 years (Rhodes, 2009)

- Reduce Dependence on Foreign Countries

The United States imports over 30% of all its energy sources according to the US Department of Energy (DOE, 2010). Fossil fuels are a large part of the United States economy and one third of it is dependent on other countries. The DOE also states that 38% of fossil fuels are imported while 62% are produced domestically. Twenty years ago, America imported about 21% of all its fossil fuels and imports amounted to only a little over 10% forty years ago (Downs, 2008).

- Creation of jobs

The integration of bio-diesel as a main source of fuel would require a completely revamped infrastructure for production, distribution, and use to meet the demand required to make integration successful. The development of this system would need man power and the goods to keep production intact. This system would offer opportunities for all types of jobs and careers. The creation of jobs and the need for more resources would allow for abundant growth and expansion. Also, as utilization of new technologies increases so does the development of alternative and supplemental usages. This, in turn creates a more expanded market and more employment opportunities.

- Market Expansion

The realm of expansion for the bio-fuel market is infinite. Research in new technologies offers opportunities for massive expansion as the limits of biologically engineered materials open new gateways to what can be done with organic material. Expansion in the growth and production of bio-fuels offer economic, production, and even agricultural opportunities for market expansion. The creation of such grand infrastructure will need the production of the goods and services required to make it possible. Bio-diesel does not only offer job opportunities in these locations, but it also helps sustain the local work force due to the ease of access of the raw materials required for production. As opportunities become available they only create more avenues to other opportunities of expansion.

- Long term Cost of Fossil Fuels

Fossil fuels are non-renewable, meaning that no matter how limited and conservative with our resources we are, eventually we will run out. This means that as supply diminishes the demand will rise and so will the price. Fossil fuels only have one direction with price, which is up. Fossil fuels will have to be replaced, the sooner it occurs, the better it will affect our environment and economy.

2.4. Negative Effects of Bio-diesel Integration

The following section will take into account the negative associated effects of integrating bio-diesel and how these effects can be altered or avoided to help make the integration more beneficial.

- Decreased food supply

Increasing the demand for bio-based fuels would also require an increased demand on the bio-based product, primarily the food stock. The food stock that we rely on, while abundant, could not stand the sudden increase of demand. Using selective amounts of our food supply would accompany our need for energy. This would require a new system to distinguish the need for human consumption, versus the need for energy production.

- Conversion Cost

Making bio-diesels commercially available to the common consumer will require conversion of the market, the production infrastructure, the products, and even the way in which it is dispersed. These conversions will be very costly and are currently less monetarily beneficial than the current product available. Given this, powerful sources needed for contribution to the advancement from most area are less likely to respond to the need to help push the advancement of making bio-diesel more marketable.

- Building a production infrastructure

If bio-diesel were to become a major power source to drive our nation's need for energy there would need to be an efficient production infrastructure to support the demand of the increased market. To build a production infrastructure of this magnitude would require a cost efficient yet productive mode of manufacturing bio-diesel. The creation of this infrastructure would require new procedure from all angles of the production chain.

- Accessibility

The industry for bio-fuels is currently dominated by petroleum based fuels and they are the predominate source by all consumers. If an integration of bio-diesel occurred it would be a struggle to make the product accessible to a wide enough variety of the market to compete with petroleum fuels. A lot of smaller businesses could not afford to convert over to bio-diesel friendly systems and also some consumers would not be willing to conform to the new change.

- Price point

Bio-diesels are in a development state which means that they are not as many well developed production procedures that can make the price of bio-diesel's price point dip below that of petro-based fuels. Petro-based fuels are the industry standard and their production processes have been updated and improved on as technology has grown. This has allowed petro-fuels as a product to move with the technology, making it easier and more efficient to produce. Bio-diesels have not had this opportunity to grow because it's small amount of acknowledgment over the years. This makes bio-diesels less efficient to produce and results in higher prices.

2.5. Neutral Effects of Bio-diesel Integration

The following effects are contributing and reactive factors that have both positive and negative effects on the possible integration of bio-diesel into a mainstream market. These factors may be quite beneficial but still have indirect repercussions on certain areas or regions of the integration.

- Economic Effects of Integration

The economic effect of bio-diesel can be very beneficial to the economy. It opens the market to many different sources of raw materials that can be used to make bio-diesels. Also with a new market come new jobs. Having bio-diesel as a primary energy source would create an abundant amount of jobs. Jobs would be created on many different levels, including production of bio-diesels, manufacturing of bio-diesel products, an increase in studies of the potential opportunities available from bio-products, etc. While bio-diesel integration could bring positive impact to the economy it could also bring negative impacts as well. If bio-diesel replaces the industry of petroleum based fuels, it would occur at the expense of a large part of our economy that is spawned by the production, utilization, and advancement of our current energy source. Bio-diesel could not immediately replace the infrastructure that petroleum based fuels built. Millions of jobs rely on petroleum based fuels. Integration of bio-diesel's would need to be carefully assessed to assure utilization of proper resource such that jobs, production methods, and educational programs are not negatively affected and appropriate decisions are made to use this product to stimulate our economy in the most efficient way possible.

- Environmental Effects of Integration

The production of fuels will have some sort of direct or indirect effect on the environment. To create energy you must use energy. Using nature's energy affects the environment and alters the manner in which biological substances interact with each other. Fossil fuels have been physically, chemically, and biologically changing our environment from the time of their utilization. These destructive forces have been altering our living spaces and harming our resources for years at the cost of our comfort. Creating and proper utilization of a fuel that could limit the amount of affliction induced by energy consumption would offer a distinct benefit to the future of our planet. Bio-diesels emit far less harmful carbon particles that are negatively affecting our atmosphere and harming our ozone layer. Although taking into account the total life cycle of bio-diesel it shows many other direct or indirect factors can limit positive environmental impact. Bio-diesel must be produced from the land, thus utilizing farm land, farm equipment, transportation, and production energy from a manufacturing plant. These production steps require a lot of resources and energy to produce. Also the secondary effects of utilization of these resources can be harmful to various areas of the environment. A method of integration must be considered where proper utilization techniques create a bridge to mend the area where this impact could be detrimental to the environment.

- Effects on Emissions

The emissions of particulate matter and harmful gases that pollute the atmosphere have been an expediently worsening issue that can be traced to the increased utilization and usage of energy. The pollutant particles associated with fossil fuels have damaged our atmosphere over the past century and affected the earth's ozone layer to an extent to cause climate change. The integration of a bio-based fuel would help reduce the carbon admittance and help preserve our air quality and the planet's climate. Bio-diesels however do emit more nitrogen than fossil fuels.

Table 2. This table shows the emission changes of different emission types as the amount of bio-diesel changes (Shumaker, 2003).

Emission Changes with Biodiesel Fuels		
Emission	**100% Biodiesel***	**20% Biodiesel Blend***
Carbon Monoxide	-43.20%	-12.60%
Hydrocarbons	-56.30%	-11%
Particulates	-55.40%	-18%
Nitrogen Oxides	5.80%	1.20%
Air Toxics	-60% to -90%	-12% to -20%
Mutagenicity	-80% to 90%	-20%
Carbon Dioxide**	-78.30%	-15.70%
* Average of data from 14 EPA FTP Heavy duty test cycle tests, variety of stock engines		
** Life Cycle Emission		

2.6. Positive Effects of Bio-diesel Integration

The following effects are associated with the positive outcomes of bio-diesel integration. These factors support the definite need for a source of renewable energy. It is important to understand that these factors are often still in developmental stages and still have lots of room for advancement.

- Replacement for Petroleum Fuels

The evident issues surrounding usage of petroleum fuels presents logical reasoning for replacing fossil fuels with a more sustainable and renewable source. Bio-fuels offer the opportunities needed to turn this projected reasoning into a reality. Bio-fuels present a competitive but still compatible structure both economically and biologically that could take the place of fossil fuels. The benefits presented throughout this paper show that such integration create opportunities while moving forward with technologies that can sustain our present and future need for energy.

- Cleaner Combustion

As proposed in the earlier passage, bio-diesel emits less greenhouse gasses and offers a better alternative to the current petroleum fuel admittance of environmentally damaging particulates. The average properly composed bio-diesel burns up to 75% cleaner than the base petroleum diesel fuel. This reduces unburned hydrocarbons (93% less), carbon monoxide (50% less) and particulate matter (30% less) in exhaust fumes, as well as cancer-causing PAH (80% less) and nitrated PAH compounds (90% less). (US EPA, 2010). The ozone-forming potential of biodiesel emissions is nearly 50% less than petro-diesel emissions and contains no sulfur emissions since it is sulfur free. Biodiesel is also a much better lubricant than petro-diesel and extends engine life. Small amount of biodiesel means cleaner emissions and better engine lubrication: 1% biodiesel added to petro-diesel will increase lubricity by 65%. Given its greater oxygen content biodiesel has a higher cetane number than petroleum diesel. The higher the cetane number the more efficient the fuel, the engine starts more easily, runs better and burns cleaner.

- Decreased Dependence on Foreign Countries

The United States imports nearly 10 million barrels of petroleum per day (EIA, 2010) This is over half of the total consumption of the country, given the massive economic effects of petroleum based energy as stated above, the creation of a domestically based energy source would create a more stable and less dependent market.

- More Competitive Open Market

The ease of availability of the common raw materials creates and influx of the products effected by the introduction of natural based bio-diesel. This will help utilize waste from over production and create a more broad market that has multiple purposes for its products. This market expansion would allow a market oriented economy for the product, which would be accessible to more competitors and would disable the current monopolistic market base that fossil fuels offer. This gives the consumers options and allows the merchants and produces more freedom for pricing from the beginning of the production process to the end. Implementing this type of market allows sustainability from each products market base to the other since they complement each other. As the opportunities grow with each production process, they begin to attract more competition as other producers become interested. With this newly appointed competition, producers become more efficient and try to outdo one another to lower their price in an attempt to grasp market share. This will result in lowering the price of the final product making it more attractive to the customer.

- Abundant Source of Energy

The rationale of moving away from fossil fuels is due to their diminishing supply and delayed capability to be replaced. The idea of an energy source that can be harvested and remanufactured offers substantial opportunities to expand our resources and recede our fears of running out of energy. The natural structure of renewable sources allows for a nearly unlimited raw material production such that the supply of the product is based on production rather that extraction or availability of the resource. This offers market sustainability and a strong support and belief in the products stability from the consumers. This stability will not only help the product but also all the products that its production makes an impression on. This process is similar to a ripple effect of a rock thrown into a lake. The products that are more directly related to bio-diesel will have greater benefits and it will decrease as the relation expands outward like a ripple.

2.7. Obstacles to Successful Integration of Biodiesel

As the inevitable integration of renewable energy sources takes place, obstacles to making the integration more profitable and logical become more apparent. The obstacles need to be evaluated in order to enable seamless integration of renewable energy sources into the mainstream. The selection of methods and timing of these processes could also determine its outcome. The obstacles and variables associated with this include:

- Economical Effects and Acceptance
- Environmental Effects and Acceptance
- Development of a Manufacturing Process that is both Profitable and Logical
- Current Market's Acceptance to the Product
- Conversion Cost of the Implementation to both the Consumer and Customer
- Affects to Food Supply
- Competing Green Technologies
- Evolution of the Technology
- Cost versus Petroleum Based Fuels

These variables have various effects on the process and certain improvements to adjust for one could either positively or negatively affect at least one other variable. The selection process should rationally develop each area such that the benefits either facilitate or cause as little negative effect as possible on the other variables.

2.8. Economic Effects of Bio-diesel Integration

The economic feasibility of the integration process is possibly one of the most important obstacles that needs to be overcome. The planning and development of such integration would need to take into account the costs and effects of introducing and increasing bio-diesel's market competence. Variables in this process include but are not limited to:

- Production cause and effects
- Consumer acceptance
- Conversion cost
- Effects to other markets
- Products life span
- Cost of competing products

As with the entire integration process, these variables must also be properly weighed and evaluated such that their effectiveness is maximized.

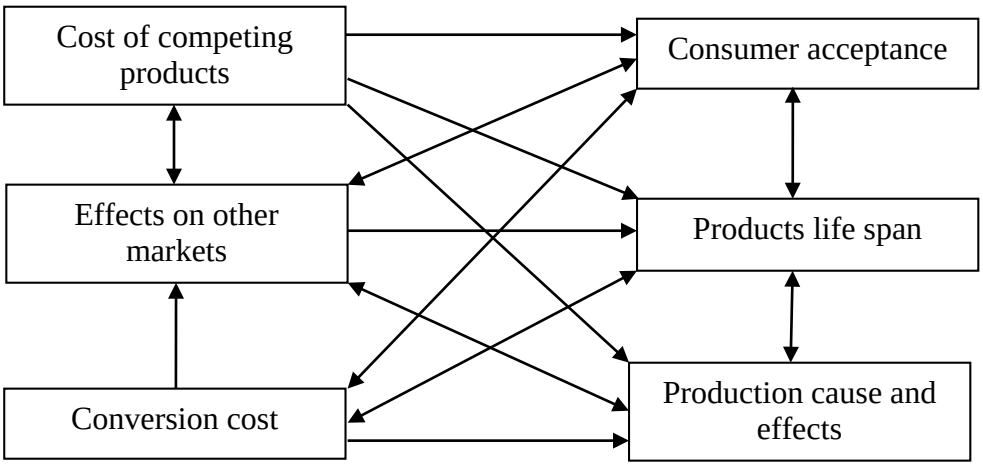

Figure 3. Functional dependency diagram depicting interrelationship between various attributes influencing economic viability of biodiesel integration.

Figure 3 presents a diagram that depicts the flow of these processes and their dependencies on one another. As expected, the consumer acceptance is a function of the overall success of most of the other processes. This is because increased

efficiency and quality will increase acceptance. Furthermore, the overall life span of the product is based on the consumer acceptance making it a function of everything else. These processes correlate with each other and a method must also be created to find the most profitable price point (measured by dollars/gallon) by utilizing all the current resources and capital created. Also to increase the transition process it is important to take into account the possible mixture combinations and possibly even post purchased additives. Below are two tables that explain the scenarios of different possible prices retail diesel per gallon compared with biodiesel and to which point it becomes more profitable than the non-mixing process. Once the production costs are recovered, the amount of profit increases with the amount of bio-diesel present in the mixture.

Table 3. Pricing structure of retail diesel compared to biodiesel (Shumaker, 2003)

Added Cost to Retail Price of Diesel Fuel when Blended with 2 Percent Biodiesel

Retail Diesel Prices Per Gallon							
	$0.60	$0.75	$0.90	$1.05	$1.20	$1.35	$1.50
Biodiesel Cost 100%	**Added Cost in Cents per Gallon**						
$1.25	0.013	0.01	0.007	0.004	0.001	-0.002	-0.005
$1.50	0.018	0.015	0.012	0.009	0.006	0.003	
$1.75	0.023	0.02	0.017	0.012	0.011	0.008	0.005
$2.00	0.028	0.025	0.022	0.019	0.016	0.013	0.01
$2.25	0.033	0.03	0.027	0.024	0.021	0.018	0.015

Added Cost to Retail Price of Diesel Fuel when Blended with 20 Percent Biodiesel.

Retail Diesel Prices Per Gallon							
	$0.60	$0.75	$0.90	$1.05	$1.20	$1.35	$1.50
Biodiesel Cost 100%	**Added Cost in Cents per Gallon**						
$1.25	0.130	0.100	0.070	0.040	0.010	-0.020	-0.050
$1.50	0.180	0.150	0.120	0.090	0.060	0.030	
$1.75	0.230	0.200	0.170	0.140	0.110	0.080	0.050
$2.00	0.280	0.250	0.220	0.190	0.160	0.130	0.100
$2.25	0.330	0.300	0.270	0.240	0.210	0.180	0.150

In the above analysis, the initial value of biodiesel mixed was 2%, the second analysis increased the amount of biodiesel by tenfold. Post analysis, it can be concluded that the tenfold increase followed as it was ten times more cost efficient once its price point became profitable. This presents satisfactory evidence that at a certain manageable price point, bio-diesel mixtures are more profitable than non-mixed diesels.

The above analysis proves that with the correct price point bio-diesel can be profitable. Similarly, given its sustainable structure it also promotes a self-reliant market that can help many other correlated markets. The proper analysis of the market is necessary to identify available resources in order to manage production location, manufacturing methods, facility size, and available human resources (Shumaker, 2003).

3. Conclusion

A detailed discussion about the widespread adoption of biodiesel was presented in this paper. Both, the benefits as well as drawbacks of such a move were duly noted. Each benefit and drawback was carefully considered from different perspectives such as environmental, economic and social. A degree of economic analysis was presented in order to justify mainstream

adoption of the aforementioned fuel. Several obstacles that could prove crucially important in the large scale shift from fossil fuels to plant and animal based fuels were noted as well.

4. References

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