An Analysis of the Use of Biodiesel to Support the Global Infrastructure as Petroleum Reserves Dry, Followed by an Experiment into the Production of Biodiesel Fueled Alternative Vehicles Through the construction of a Biodiesel Sidecar

The lust for energy and power as our economy and technology expands is causing humanity to act very self-destructively, using ancient carbon deposits and spewing their noxious emissions into our steadily warming atmosphere. It is obvious that we cannot sustain our hunger on petroleum and fossil fuels forever, and to overcome our imminent downfall as our oil reserves deplete, we must look to alternative fuel sources to support ourselves until the energy crisis can be solved permanently. As our non-renewable fuels dry up and our atmosphere fills with their exhaust, we must look to renewable and clean bio-fuels such as biodiesel to supplement our energy use.  
 The first step to utilizing biodiesel to support our infrastructure is understanding its history, production, and advantages. Today, biodiesel is a fuel used in compression ignition engines which is derived from feedstock and economically non-competitive oils. These sources are most often vegetable oils, animal fats, or algae biomass composed primarily of lipids and triglycerides. This fuel can be mixed in proportion to petroleum in order to supplement standard diesel. (Kemp, 165) “Biodiesel is the product obtained through the transesterification of animal fats or vegetable oil, yielding fatty acid methyl esters or FAME” (Kemp; 107) The process of transesterification is where the fat molecule in the form of a glycerin molecule bonded to 3 fatty acids (hydrocarbon chains) is torn apart by the addition of methanol alongside an alkaline catalyst such as sodium or potassium hydroxide, resulting in the transfer of each fatty acid to a methanol molecule and leaving the glycerin byproduct which is then filtered out. The chemical properties such as viscosity and free fatty acids (FFAs) of the resulting liquid are dependent on the type of oil or fat used. (Kemp; 108-9)    
 **Biodiesel was the original fuel intended to be used in diesel engines, as Rudolf Diesel, the inventor of the diesel engine had originally used peanut oil to demonstrate his newly invented engine at the 1900 Paris World Fair (A.P. Chalkley; *1-8***) While Rudolf Diesel used peanut oil, our production process of biodiesel is based upon a chemical reaction called transesterification.  
 **Biodiesel has undergone 3 generations since the discovery of transesterification in 1853, when two chemists, E. Duffy and J. Patrick, experimented with the process while trying to make soap. (**History of Biofuels) The 1st generation was based upon food-stocks, or human consumed food oils. This generation was not useful because it competed with food markets to produce biodiesel, which made the cost of biodiesel unfathomable. Second generation biodiesel was generated from feed-stocks, which is raw natural biomass which is processed specifically for use in biodiesel. These feed-stocks did not compete with markets to the extent that food-stocks do, but their competition at all still made biodiesel inconvenient at higher production rates. Lastly, third generation biodiesel depends on algae biomass with high triglyceride content such as Chlorella. Third generation biodiesel has recently been developed, and promises a green biofuel which does not compete with any industries for their feed-stocks, making it affordable as well.  Since biodiesel has always been limited by the cost of production, which is mostly dependent upon the generation of biodiesel being produced, it can now be competitively cost effective to produce and use when compared to diesel.   
 This comparison between diesel and biodiesel is becoming ever more important as biodiesel begins to offer an affordable, renewable, ecologically friendly fuel alternative from the polluting petroleum used so recklessly. Petroleum diesel is a derivative of crude oil, which has been refined through the careful distillation of the oil in order to separate the different hydrocarbon molecules by taking advantage of their varying boiling points. (Kemp; 59) The end result of the refining and treatment of the crude oil are saturated and aromatic hydrocarbons. (A-Z index, *TPH*) Compared to this, biodiesel is a much cleaner fuel, containing less sulfur oxides and sulfates while producing fewer unburned hydrocarbons, carbon monoxide and particulate matter. The improved emissions can be credited to the inherently higher purity of biodiesel. (Kemp; 86) In addition, the U.S. Departments of Agriculture and Energy have conducted studies on the lifecycle of biodiesel, and how its emissions affect our atmosphere. They found that while biodiesel is slightly less energy efficient when produced, the CO2 emissions, particulate matter, and carbon monoxide emissions are all lowered.  (Sheehan; 33)  
            Biodiesel can generally be used in all modern diesel engines, post 1992 of course. This is because natural rubber, which is susceptible to degradation in contact with biodiesel, stopped being used in 1992. Since then, biodiesel has been used in various mixtures with petroleum diesel, partly supplementing the use of fossil fuels. Biodiesel/petroleum diesel mixtures are referred to by BXX where XX is the percentage of biodiesel in the mixture (B20 = 20% biodiesel, B100 refers to 100% biodiesel). Biodiesel fuels can be used in virtually all diesel engines, and the application of new vehicle designs integrating diesel engines will allow the promising fuel to become more common as the world begins to demand renewable, affordable, and environmentally friendly energy sources  
 Now that we have a basic understanding of biodiesel, we now must look at the fundamental role of biodiesel in relieving the world’s addiction to fossil fuels. Oil, followed closely by coal and natural gas, is the most widely used fuel in the world. Oil is a very general fuel source, and is refined and distilled to separate it into different fuels like gasoline and diesel, and lubricants like grease and motor oil, along with countless other uses. This refining process is very costly and produces harmful byproducts which are carelessly disposed of. It becomes very obvious that oil and petroleum are inefficient, and when compared to biodiesel, the advantages become clear.

In first world countries, diesel is used in large vehicles and heavy machinery, as the higher torque, durability, and size is a necessity for their purpose. However, in second and third world countries, diesel is an extremely common fuel source for transportation and power. The purity requirements of diesel engines are much lower than that of gasoline engines, and are increased even more so when biodiesel is used inside these engine. Lower purity requirements allow the price and quantity of diesel fuel to be lower and higher respectively in non-first world countries. Therefore, the biodiesel industry could grow well in poorer and poverty stricken areas.

Since biodiesel has the potential to support our starving infrastructure, both in first world countries like the US for a very short time, and poorer, more rural countries indefinitely. However, biodiesel is only a temporary solution, since smog forming emissions such as nitrous oxides will cripple our environment as badly as carbon oxide emissions. Biodiesel has the potential to support both the trucking and rail industries, allowing trade and transportation through a dark, gasoline shortage.

I have found petroleum usage to be analogous to a drug addiction, in which the U.S. and other high-energy consuming countries are the addicts, the petroleum rich countries like Saudi Arabia are the drug dealers, and climate change is like the impending overdose, bringing the world to a stop. The only difference though, is that the world is addicted to oil, not a drug.  To continue the metaphor, biodiesel is like methadone to a drug addict, perhaps it can relieve our needs just long enough for the world to switch to more ecologically friendly fuels.   
 If this remarkable biofuel has the ability to wean us off our oil addiction, we should still look to reduce our carbon and ozone destroying emissions while making this technology more available. To do this, we must increase our vehicle efficiency and affordability with new and ingenuitive designs. It is important to remember that biodiesel is only a temporary solution to the energy crisis on a global scale. While small scale biodiesel production is just a drop of water in the ocean, mass production of biodiesel could lead to the slowing of global climate change in some aspects.

Biodiesel seems very appealing, but the real challenge is convincing the world to convert, and humans do not change easy. Since large scale first or second generation of biodiesel production is not economical in most situations, third generation biodiesel will be the main focus of this theorization. First, diesel engines must be more widely available, as their main use in first world society is for infrastructural purposes such as trucks, trains, and generators. Their use in smaller consumer vehicles pales in comparison to their industrial usage, as gasoline engines are more affordable to manufacture and fuel. Light duty vehicles produce 61% of greenhouse gasses in the US, while trucks, trains, ships, and aircraft make up the rest. (*Car Emissions,* UCS) Therefor, any emissions reducing method would be applied first to the smaller industries, which biodiesel has, mainly due to the simplicity of fuel substitution.

Biodiesel could be used in alternative transportation such as motorcycles, micro-cars, and sidecars. These are all fuel efficient vehicles due to their low mass, efficient and small engines, and specified tuning for city driving, allowing up to 140 mpg in some vehicles. (*The Vintage…*) The majority of motorcycle and sidecar engines are all gasoline, while some microcars can be found with small diesel engines, such as the aixam microcars, incorporating Kubota 2 cylinder diesels in a small, lightweight, smart-car like design. These allow for upwards of 76 mpg of diesel fuel, and when filled with biodiesel and combined with advanced catalytic converters and filters, the emissions per gallon of fuel are very close to nil. (*Total Motorcycle*) This is only one of the many advancements in fuel efficiency in alternative vehicles, as motorcycles commonly push 100 mpg while still retaining their rocket ship-like abilities. Can-ams, spyders, and other versatile, stable, compact and efficient 3 wheeled vehicles are being developed and consumerized as this is written.

Unfortunately for biodiesel, gasoline engines cannot be easily converted to diesel fuel due to the higher compression ratios and longer stroke as outlined previously. This means that any existing gasoline vehicles could not be converted, implying that any growth in the use of biodiesel among consumers must be preceded by a growth in the consumer diesel engine industry. We can then extrapolate that any mass production and consumption of biodiesel will rely heavily upon automotive manufacturers in the 21st century

My research into biodiesel led to thinking about the possible applications of diesel engines in alternative vehicles. Alternative vehicles tie into home-brew biodiesel very well, as their small economical nature and generally simplistic construction allows for them to benefit from increased fuel efficiency. Combining a low cost, efficient vehicle with a renewable energy source such as biodiesel is the obvious next step when considering the two technologies at hand.

My first thought when producing an alternative vehicle is a sidecar. Upon further theorization, a sidecar offers an open platform and an abundant supply of parts available to me. In essence, all that is required to produce a prototype of a biodiesel sidecar is a small diesel engine, a gasoline powered motorcycle and sidecar combination, and a power train capable of adapting the low RPM/high torque inherent in diesel engines. However, to produce an extremely efficient and road worthy biodiesel powered alternative vehicle, the parts would need to be specifically manufactured for the machine. I decided, since this vehicle is a prototype, intended for demonstration of the possibilities of the technology, I decided to use a more simplistic design to accommodate the short time frame. This simplification can be noted in changes to the powertrain and accessory systems. The main differences between the ideal design and the prototype produced is the clutch and transmission. A biodiesel sidecar that is to maximize fuel efficiency would incorporate a specifically designed multi-geared transmission with ratios to accommodate the torque and rpm of the diesel engine and rear wheel output. In comparison, the prototype incorporates a centrifugal clutch and single gearing in order to expedite the connection between the engine and the rear wheel. This is then connected with 428 chain to the large rear sprocket, completing the powertrain. The sidecar will then be fitted with a miniaturized biodiesel reactor and finalizing the crude prototype of a biodiesel sidecar.

In conclusion, a biodiesel sidecar is a very viable design for future personal transportation, as biodiesel offers renewability, and the motorcycle and sidecar offer a versatility while retaining fuel economy. While microcars and small diesel engines have already been utilized for local transport, the main focus of this study was into the potential for biofuel to function as a crutch for the world’s drying petroleum reserves. Throughout my research I have concluded that biodiesel not only may support our failing petroleum based infrastructure, but with advancements may lead to more renewable, environmentally neutral fuels.