HOME AND WATER HEATING USING BIOFUELS

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Abstract: The use of biofuels as a renewable energy resource has been gradually increasing globally in the past decade though not as rapidly as it could potentially be. This project looks into the idea of exploring the use of biofuels for water and home heating systems to promote the advantages of using such alternative energy resourcing. Conventional home heating oil burner system that traditionally uses petroleum oil can be used with biofuels instead. The locality of its production has also been explored; Malaysia and United States are compared as both are main producers of biofuels of different types depending on each land's local crop resources. Many advantages and the viability of using biofuels instead of petroleum oils have been discussed in this report.

Keywords: Biofuel, Biodiesel, Recycled, Renewable, Economy, Malaysia, United States, Home-Heating, Systems

I. INTRODUCTION

Updates on technological advances cannot be kept up by many as these developments are ever-increasing in number exponentially as there are new technological advances discoveries on a daily basis providing us with new and exciting ways to improve our lives better and make living easier. Despite these advances, we are still way behind in sustainability efforts. These advances are mostly only bad for the ecological system to subsist as current generations' lifestyle consists mostly of using non-renewable energy resources. 90% of global energy generation is produced from fossil fuels, creating bad greenhouse gases that have been proven to harm our fragile health and pollute our environment viciously [1]. To make a world of modern technology in a sustainable and healthy environment without damaging our mother earth is a dream far-fetched. In spite of the fact, there are many organizations and efforts around the world that are directed towards decreasing the effects of these oblivious civilization advancements. Home heating uses a big amount of energy. There are many reasons to why biofuel is a prominently superior alternative to petroleum oil and the comparison between the two is done in the comparison section. The source of fuel for these systems would mainly consist of vegetable oils; mostly from soy or corn and recycled used cooking oil from factories, restaurants and homes that usually turn into mere waste. Though more well-known and introduced widely as biodiesel, a sustainable alternative source of energy for car fuelling for diesel-engine vehicles, this method of energy resourcing has also been implemented in houses for home heating especially in the United States, using the conventional home heating furnace or water heater without any need of alterations which is among the remarkable advantages. Recent researches have shown that the viability of implementing the use of this renewable source of energy worldwide in the future is towering. Up to this day, 21 countries worldwide, mainly European countries and the United States are known to have ongoing projects on commercialising the use of such energy resource [2]. It is a no-wonder as it has many advantages compared to the use of petrol-based oil itself. Noteworthy advantages include: clean source of energy as it is less polluting; renewable source of energy as it comes from crop and waste created everyday and would not run out any time soon; better lubrication power for better engine life; can be blended with other energy resources. This method is also a great alternative of energy resources economically for places that do not have the advantage of reserving crude oil.

2. Biofuel as an Alternative

Biofuel is a high in demand source of energy alternative to petroleum oil. It is produced from organic matters; usually from crops and recycled vegetable oil. There are many types of biofuel that are produced globally. Biodiesel for instance, is a type of biofuel made for diesel-engine vehicles or home heating furnaces. It is made of vegetable oils, usually crops like corn or soya or recycled cooking oil. It can be used to run any oil burner home heating systems or diesel engines[3].

2.1 Increasing global production

Biofuel is a cleaner option because it produces less of these greenhouse gases and also renewable, since its resources are reproducible easily and would not run out. Its many advantages make it a well looked into alternative and put it well on top of the market as time advances. The figure below shows the ever increasing biofuel production since the start of its production in 1990. As can be seen, its production has been increasing exponentially with time [4]. Figure 1 below shows the production of biofuel globally from the year 1990 to 2011 [3]. The production is seen as exponentially rising with time globally.

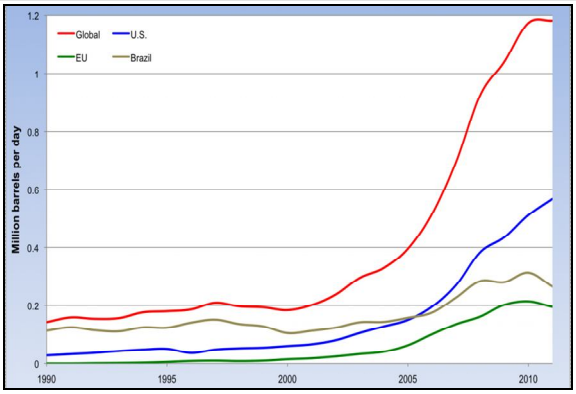


Figure 1. Global Biofuel Production 1990-2011

Its production is increasing in such a positive way due to many reasons. Developing countries are driven to produce biofuels because it create more varieties of energy resources and of course makes their economy self-dependant as the price of oil fluctuates from time to time and affects their countries' economy greatly. The farms of the crops for these biofuels also give chance for a great number of employments; be it in the producing feedstock, the manufacturing of biofuel, the transporting and distributions of the products. Besides that, it is proven that there is also less pollution that is vicious creating better air quality compared to petroleum-based oil [5]. It can be summarised that biofuel as an alternative fuel is renewable and clean, lower harmful gases emissions for better and cleaner air, more efficient in heating systems compared to petroleum-based oil, better for heating systems health and maintenance, and makes the economy independent by not relying on foreign supply of petroleum.

2.2 Disadvantages and concerns

Despite its many advantages, there are always disadvantages and concerns that should be considered. The raw material for biodiesel comes from crops which mean a clear land that involves cutting rainforests is involved and that is harmful to the environment[6]. A question rises that is biofuel actually totally beneficial as presumed if these consequences are being put into the picture. Also, the productions of vegetable oils from corn and soya for biodiesel takes away these amounts of crops quoted for food which leads for food scarcity for people who are dependent on these crops [7]. This problem though can be solved by using more waste products like recycled cooking oil and fats from restaurants and food processing factories to produce the raw material. Hence, less harm is made to environment and it would not disturb the food chain apart from creating less wastage.

3. Petroleum versus Biofuel

The advantages of biofuel compared to petroleum are of substantial amount. It is a cleaner source of energy, renewable, comes from crop and waste created everyday, it would not run out anytime soon. It is also great for the local economy for places that do not reserve crude petroleum oil. Besides that, it can also be blended with other types of oil to fit its purposes and for the betterments of its usage. Apart from these reasons, below are some summaries of some of ongoing tests and research have been done proving that biofuel is in fact better for the environment and engine life.

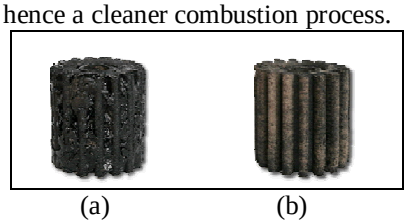
3.1. Less lifecycle carbon emissions and other pollutants

To the highest advantage, all biofuels also do not contain sulphur[8]. Compared to petroleum-based fuels, biofuel is proven to have reduced amount of pollutants produced as by-products. Transportation produces most pollutants to the modern air quality, and this notes the importance of using a better alternative to fossil fuels. Tests showed that using a biofuel mix in home heating oil burner results in a massive reduction in pollutants such as carbon monoxide, hydrocarbons and other pollutants compared to using petroleum-based oil. The lifecycle carbon emissions for biodiesel are greatly reduced as biodiesel made of recycled and used oil produces an extensive 80% less carbon compared to petroleum fuel[5].

Ethanol and biodiesel for instance contributes to least air pollutants; it produces less carbon monoxides and hydrocarbons[9]. It also replaces lead for octane in petroleum which is harmful. This is one of the reasons why these two types of biofuels are the most in demand globally.

3.2. Better Lubrication for Longer Engine and Equipment Life

Biofuel has better lubrication power for better engine life[10]. Its higher lubrication in biodiesel compared to petrol-diesel makes the engine life lasts longer. Figure 2(a) and 2(b) below shows two filters that were removed from home heating apparatus that have been used for a year [11]. The one on the left has been used with petroleum oil only, and the other had been used with biofuel of 2% biodiesel. It is known that biodiesel replaces the need of harmful additives to the oil and creates less pollutants and particle matters hence a cleaner combustion process.



(a) (b)

Figure 2(a). 100% petroleum system filter, (b). B2 bioheating oil system filter

As can be seen, the effect of harmful additives and particulate matters in petroleum based oil is nonexistent in the cleaner biofuel blend oil. Not only it is proven better for equipment's life, but it also lessens the maintenance cost and new filters. The cleaner biofuel is better for longer and healthier engines.

4. Biofuel for Home and Water Heating Oil Burner System

Conventional home heating oil burner traditionally uses petroleum-based oil for combustion, known for its pollution of greenhouse gases. Biofuels can be used with conventional oil-based home and water heater. This is one of its main advantages as no change in the systems is required; just fill in a biofuel blend in the oil tank instead of a 100% petroleum oil. The oil tanks for home heating apparatus does not need to be cleaned first, the use of biodiesel blend up to 20% can be used at any time[12]. The demand of using biofuel for home heating has grown and so as the suppliers especially across the United States.

4.1. Oil based home heating system

Oil heating is popular due to its little space of storing, no handling required and it leaves no ash compared to coal and other burning fuels. Figure 3 shows a schematic diagram of the inside of a pressure-type oil burner[13]. It is the most common type used for home-heating. From the diagram, it is shown that the pump lets oil through the duct and filter, and the blower would blow air into the combustion chamber, and the igniter would spark and creates combustion to put heat in the heat exchanger.

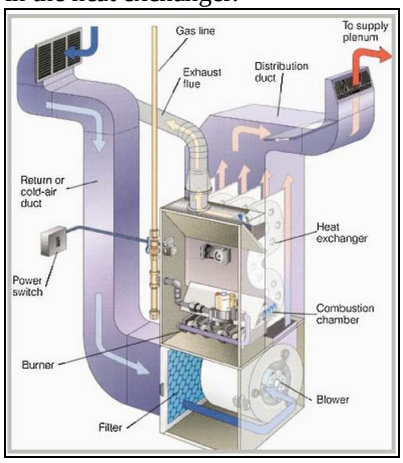


Figure 3. Home Heating System

4.2. Oil-fired Water Heater

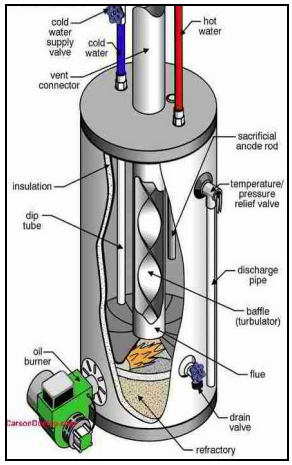


Figure 4. Oil-fired water heater

This system is less popularized compared to the more commercialized electrical water heater system. On the other hand, the means of using oil as the fuel for water heating would mean independency from electricity needs and to the use of a lot of electricity and its bill costs while using recycled cooking oil instead to get the same hot water at home. Figure 4 above show a schematic diagram of an oil-fired water heater system[14]. This system works by pumping cold water into the radiators after being set to heat. The oil burner is turned on when the temperature is detected to have dropped and will heat the water with combustion in the combustion chamber. The flue acts as a duct to convey the heat to heat water in the tank. The hot water then goes through the outlet.

5. Types of biofuels: comparison between bioethanol and biodiesel

There are many types of biofuels that can be used but the two most common ones and covers 90% of the global usage are bioethanol and biodiesel [15]. Figure 5 below shows the flow diagram of the manufacturing process of both bioethanol and biodiesel[12].

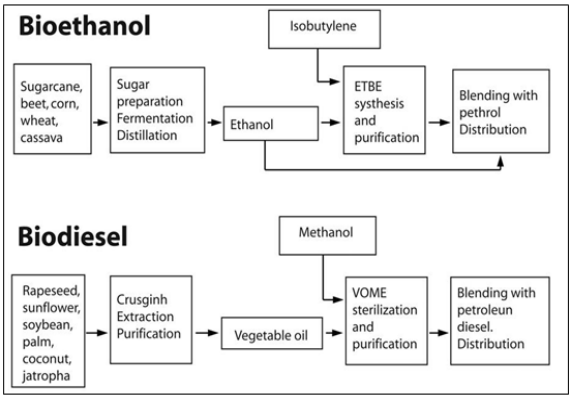


Figure 5. Manufacturing process of bioethanol and biodiesel

5.1. Bioethanol

Bioethanol or ethanol is produced from fermented sugar or its plants and crops. These include sugarcane, corn and wheat. It can be mixed with petroleum and to be used in commercialized diesel engines or in its pure form in modified engines. Popular bioethanol blends are of 5 and 10% blend in petroleum and are called B5 and B10[15]. The blend of up to 10% of ethanol reduces the system's dependency on gasoline.

5.2. Biodiesel

The reaction of vegetable oil with ethanol or bioethanol produces a Biodiesel or vegetable oil methyl ester (VOME) with the help of a catalyst to yield mono alkyl esters and glycerine which is removed later[15]. Oily crops or trees such as palm trees produce organic oil. Oil can also be produced

from animals and recycled from waste products such as wasted cooking oil. Biodiesel can also be used in pure form blended with automotive diesel similarly bioethanol. These oils can be used easier in home and water heating systems as these systems are way simpler than automotive engines and do not require as much maintenance and running requirements.

5.2.1 Recycled cooking oil: Recycled cooking oil is a type of biodiesel, and needs to be filtered and dewatered to be commercially sold. For home and water heating, the oil can be filtered using any filter to get rid of particulate matters of food before being used in the boiler tanks. Commercialized biodiesel removes the glycerin contained in the used cooking oil before being used [8]. This is because glycerin freezes and only melts at very high temperatures. Without being removed, the flow and viscosity of the biodiesel would be disturbed. Like fossil fuel, with pure biofuels, one unit of energy extracted means one unit of energy produced and back. There are varieties in these units of energy with different types of biofuel. There are many more tests and research being done to get the best out of biofuels to get more units of energy back out of a single unit to make a more efficient product for fuels.

6. Viability comparisons: Malaysia vs. United States

Different countries around the world produce different types of crops to produce biofuel. In this section, the viability of different types of biofuel crops in Malaysia and the United States is compared. In the United States, crops that are grown can be most effectively used to produce bioethanol. On the other hand, Malaysia has crops that are used to produce more biodiesel than bioethanol.

6.1 Ethanol and biodiesel in the US

Biodiesel is a legally registered fuel and fuel additive with the U.S. Environmental Protection Agency (EPA). EPA registration includes all biodiesel that meets ASTM D6751and is feedstock neutral. The federal Renewable Fuel Standard requires at least 1 billion gallons of biomass-based diesel consumption in the U.S. (at this time, biodiesel comprises the vast majority of biomass-based diesel in the US). The RFS required 1.3 billion gallons of biomass-based diesel in 2013[16].

6.1.1 Starch- and Sugar-Based Ethanol Production: Most ethanol in the United States is produced from starch-based crops by dry- or wet-mill processing. More than 80% of ethanol plants are dry mills due to lower capital costs[17]. Dry-milling is a process that grinds corn into flour and ferments it into ethanol with co-products of distillers, grains and carbon dioxide. Wet-mill plants primarily produce corn sweeteners, along with ethanol and several other co-products (such as corn oil and starch). Wet mills separate starch, protein, and fiber in corn prior to processing these components into products, such as ethanol.

6.1.2 Cellulosic Ethanol Production: Making ethanol from cellulosic feedstock such as grass, wood, and crop residues is more challenging than using starch-based crops. There are two primary pathways to produce cellulosic ethanol: biochemical and thermochemical[16]. The biochemical process involves a pretreatment to release hemicellulose sugars followed by hydrolysis to break cellulose into sugars. Sugars are fermented into ethanol and lignin is recovered and used to produce energy to power the process. The thermochemical conversion process involves adding heat and chemicals to a biomass feedstock to produce syngas, which is a mixture of carbon monoxide and hydrogen. Syngas is mixed with a catalyst and reformed into ethanol and other liquid co-products[17].

6.2. Malaysia's Palm Oil as Biodiesel

The World Commission on the Environment and Development states that sustainable development is the development that 'meets the needs of the present without compromising the ability of future generations to meet their own needs'[18]. Legal, environmentally appropriate, economically viable and socially beneficial management and operations are compromised by a sustainable oil production. Therefore, Malaysia mostly depends on the vast resource of sustainable palm oil for the production of a sustainable palm biodiesel and thus holds a sustainable and efficient biofuel industry. Palm biodiesel is renewable, biodegradable, non-toxic and safe to handle and essentially free of sulfur. It also provides a safety net to stabilize the price of palm oil by removing surplus stock. In other words, it contributes to way lesser pollution relatively.

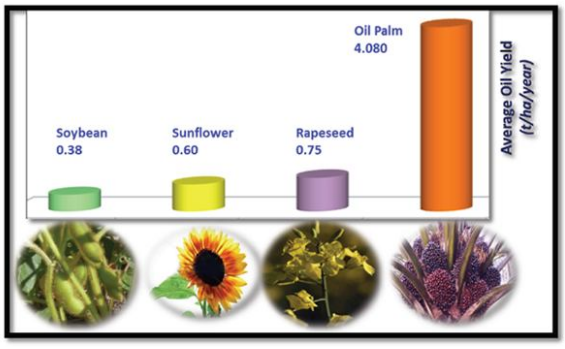


Figure 6. Palm oil as the most productive Malaysia's oil crop

Figure 6 above shows different types of biofuel crops that are grown in Malaysia[19]. The types include soybean, sunflower, rapeseed and oil palm, in order of increasing production. Malaysia currently accounts for 39 % of world palm oil production and 44% of world exports[19]. If taken into account of other oils

& fats produced in the country, Malaysia accounts for 12% and 27% of the world's total production and exports of oils and fats. Being one of the biggest producers and exporters of palm oil and palm oil products, Malaysia has an important role to play in fulfilling the growing global need for oils and fats sustainably[20].

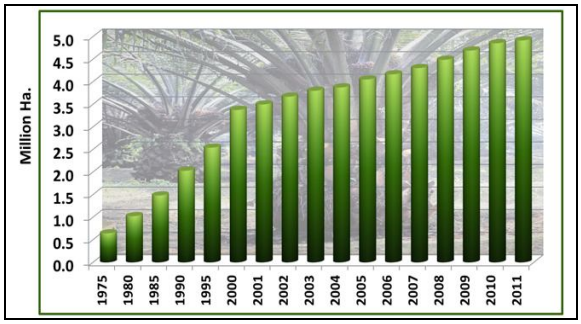


Figure 7. Planted palm oil area in Malaysia

Figure 7 above shows the planted palm oil area in million hectares unit in Malaysia within the year of 1975; the start of Malaysia's palm oil production, to the recent year of 2011[20]. All in all, Malaysia has the right hand of outsourcing palm oil resource as biodiesel globally.

6.3 Comparison between Malaysia and the United States

Table 1 below shows the amount of biofuel production in respective countries from year 2009 to year 2014 retrieved from U.S. Environmental Protection Agency (EPA)'s website and Malaysia's Biofuels Annual report respectively[16][19]. These data are evaluated and compared in Figure 8.

Year	Malaysia	United States
2009	241314	42000000
2010	86,960	49000000
2011	55,437	52800000
2012	152,180	58000000
2013	379,363	62600000
2014	642,417	68700000

Table 1. Biofuel Production in Malaysia and the United States within year 2009 to 2014

Figure 8 below shows the comparison between the two countries, Malaysia and the United States in terms of their biofuel production per land size in recent years, hence presenting their land productivity for biofuel crops. As can be seen, the production of biofuel in United States is a lot higher than Malaysia's production of biofuel. This can be due to a few reasons; the small land area of Malaysia compared to United States and the technology advancement of renewable energy according to the respective countries' development. The United States is a more advanced and developed country whereas Malaysia is a developing country. Besides that, Malaysia produces and supplies its own petroleum oil while United States depend on foreign oil. This explains the large production of biodiesel in United States compared to Malaysia.

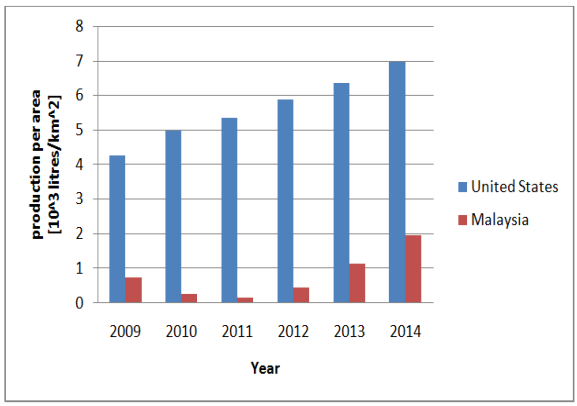


Figure 8. Biofuel production per unit area of land in Malaysia and United States

CONCLUSION

Recent researches have shown that the viability of implementing the use of biofuels as renewable source of energy worldwide in the future is towering. Many usages of alternatives resources of petroleum oil have been implemented. This is due to the petroleum oil depletion the human race is facing. Many alternatives to fossil fuels have been researched and explored to overcome oil scarcity. Biofuel has its advantage because many fuel applied machineries and systems are oil-based which means little or no modifications are required on the machineries to change to this type of alternative energy resourcing. To conclude, the hypotheses that biofuel is better for water and home heating is indeed supportable. No system modifications in these heaters are required. At the same time, it reduces the dependency on the electricity from the grid as heating requires a lot of energy. Biofuel is also a great oil alternative in terms of locality productions as it promotes local supply of fuel resources. The comparison between the productivity of biofuel in recent years in Malaysia and United States shows that United States produce a lot more biofuel than Malaysia. This is due to reasons such as its bigger land area for growing crops, technology advancements, country advanced development and its dependency on foreign oil. Biofuel has been promoting better local economy, creating endless job opportunities for these countries.

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