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Biodiesel as an Alternative Energy Resource in Southwest Nigeria

Idusuyi, N, Ajide. O.O., Abu, R.
Mechanical Engineering Department, University of Ibadan, Nigeria

ABSTRACT

The Nigerian state faces unique issues that may provide an opportunity for rural economic growth. One of such is that major urban areas in the southwest of the country are beginning to have population increase and hence air quality problems that will require actions to reduce sources of pollution. One major pollution source is from exhaust emissions from cars and trucks. The use of alternative fuel sources such as biodiesel can make a significant reduction in certain exhaust emissions thus reducing pollution and improving air quality. The opportunity for economic growth in a single product economy like ours could lie in the processing of soybean oil and other suitable feedstocks produced within the country into biodiesel. The new fuel can be used by vehicles traversing the country thus reduce air pollution and providing another market for agricultural feedstocks while creating a value added market for animal fats and spent oils from industrial facilities. The benefits of biodiesel go far beyond the clean burning nature of the product. Bio diesel is a renewable resource helping to reduce the dependence of the economy on limited resources and imports, create a market for farmers and reduce the amount of waste oil, fat and grease being dumped into landfills and sewers.

Keywords: *Biodiesel, Soybean, Feedstock, Renewable Resource and Air Pollution*

1. INTRODUCTION

Biofuels are liquid transportation fuels made from plants and animal residues used for car, trucks, airplanes and trains [1]. The primary sources of biofuel are ethanol and biodiesel. Ethanol known as ethyl is an alcohol produced from renewable feedstocks such as cassava, maize, sorghum, and potatoes. Biodiesel on the other hand is a light to dark yellow liquid immiscible with water, with high boiling point and low vapour pressure. It also refers to a diesel – equivalent processed fuel derived from biodiesel sources (such as vegetable oils), which can be used in unmodified diesel – engines vehicles. It is also biodegradable, non-toxic and typically produces about 60% less net carbon dioxide (CO_2) emissions than petroleum – based diesel [2]. The American Society for Testing and Materials (ASTM) defines biodiesel fuel as monoalkyl esters of long chain fatty acids derived from a renewable lipid feedstock, such as vegetable oil or animal fat. ‘‘Bio’’represents its renewable and biological source in contrast to traditional petroleum-based diesel fuel; ‘‘diesel’’refers to its use in diesel engines [3]. As an alternative fuel, biodiesel can be used in neat form or mixed with petroleum- based diesel. In fact, the concept of biodiesel dates back to 1912 when Rudolf Diesel (the invention of the first diesel engine) stated that “The use of vegetable oil for engine fuels, may seem insignificant today but such oil may become, in the course of time, as important as petroleum and the coal-tar products of the present times.”[2]. Specific sources of biodiesel are coconut oils, jatropha, soyabean oils, cotton seed oils, and beniseed oils. The use of biofuel reduces air toxic gas emissions radically and green house gas buildup. Highlights of the specific features of the *Jatropha curcas* plant and its potential for the production of biofuel, protein concentrates as livestock feed and value-added products that could enhance the economic viability of Jatropha seed oil-based biodiesel production was reviewed by Harinder et al [4].The review elucidated the roles of the plant in carbon capture, enhancing socio-economic conditions, food production in the tropical regions, and influencing microclimate, vegetation and soil quality .The study was able to show a comparative account of the toxic and non-toxic genotypes of *Jatropha curcas* from their physical and chemical characteristics as well as their potential for biodiesel and livestock feed production. Compared to automotive gas oil (petroleum-based diesel), biodiesel has a more favourable combustion emission profile, such as low emissions of carbon monoxide, particulate matter and unburned hydrocarbons. Carbon dioxide produced by combustion of biodiesel can be recycled by photosynthesis, thereby minimizing the impact of biodiesel combustion on greenhouse effect.

1.1 Benefits of Biodiesel

According to Zhang et al [3], there are several benefits to using biodiesel as a blended fuel in diesel engines:

- Biodiesel has a lower flash point than petroleum diesel and thus helps prevent damaging fires.
- Biodiesel burns cleaner than petroleum diesel and thus reduces particulate matter and lowering emissions of nitrogen, carbon monoxide and un-burnt hydrocarbons.
- The odour of burned biodiesel fuel is considered by many to be less offensive than petroleum diesel.
- There are only limited or no needed modifications to current engines to be able to use biodiesel, as it allows longer engine life and produces higher cetane.
- There would be no need to change the transportation and storage systems to handle biodiesel
- Biodiesel gives almost equal engine performance and mileage as petroleum based diesel, dissipating engine heat faster, with more hours between oil changes.

1.2 Potential Drawbacks to Biodiesel

Biodiesel can be corrosive to rubber and liner materials .It cannot be stored in concrete lined tanks. In some cases, the fuel intake orifices may need to be reduced in size to create a higher cylinder pressures. These and many others alike could be minimized through active engagement in research.

2. RECENT DEVELOPMENTS IN BIODIESEL RESEARCH

There is growing interests among the world researchers in the developments of biodiesel. Energenics is a marketing research group in Singapore set up with the aim to identify, invest, source, validate and commercialise energy technology. The hallmark goal of the group was to improve the use of conventional sources to reduce emissions and use of alternative energy solutions to benefit the environments and customers [5]. The group painstaking research efforts gave insights for developing Energdiesel^{TM} which is 28% biofuel (20% biodiesel and 8% ethanol),EnerCET(fuel and lubricant additives) which is a premium cetane booster on natural compounds and ENERCAT which is a cerium based nano catalyst offering more percentage fuel efficiency.Woulandakoye et al [6], researched on producing vegetable oil and subsequently biodiesel from Jatropha Curcas seeds, using both mechanical and solvent extraction methods. Results obtained from their study showed that solvent extraction produced high quality oil than mechanical extraction. It was also found that parameters such as oil temperature, reaction temperature, ratio alcohol to oil and purity of reactants are factors that affect the transesterification process and that the use of KOH instead of NaOH as catalyst gave more quality biodiesel. Highina et al [7] paper examined the potentials of liquid biofuels as alternative transport fuel in Nigeria. The authors opined that the Nigerian transport sector is probably the most vulnerable sector , as it responds very sensitively to rises in prices of conventional fuels, most of which are today imported into the country, though ironically, Nigeria is the world's sixth largest exporter of petroleum crude.This has necessitated the search for renewable, sustainable and environmentally friendly energy resources. The research presented a comparison between fossil fuels and liquid biofuels in terms of availability of raw materials, technique of production, fuel properties and environmental hazards in Nigeria. The authors concluded that liquid biofuels have more merits over fossil fuels use in the transport sector of Nigeria's. It is evident from this authors' work that there is great need to develop Nigerian indigenous technology to improve our immense biofuel potentials. Agboola and Agboola [8] carried out a critical review of the state of bio-ethanol developments in Nigeria and offered recommendations to help sustain this trend of development. The study reported that while there is a target of 1.27 billion litres of ethanol per year to be blended with petroleum, the government is doing little to increase cassava production and cassava extraction efficiency. The review showed that average yield of Nigeria's cassava stands at 15 tonnes per hectare compared to countries like Brazil with an average of 35 tonnes per hectare. It is obvious that the government lacks comprehensive policies to tackle the challenges that ethanol development will pose to the citizenry. Based on this, the study provided recommendations for policy makers in order to aid fast formulation of sustainable bio-ethanol policy for Nigeria.

3. JUSTIFICATIONS FOR BIODIESEL PRODUCTION

The recent research developments in the exploitation of biodiesel especially in Nigeria and the rest of Africa provides a reliable platform for adoption of biodiesel as an alternative energy source in the southwest Nigeria. The following could be key reasons to adopt and promote biodiesel production and research;

3.1 Availability of Feedstocks

The availability of vast biodiesel resources such as Soybeans, *Jatropha* and other crops in Ondo, Oyo, Ekiti, Osun and Ogun ,Southwest Nigeria has a reliable potential for production of biodiesel that will immensely helps in its utilization as an alternative energy resource.

3.2 Global Warming

Another key justifiable reasons for embracing and promoting the use of biodiesel in southwest Nigeria is Global warming. By global warming we mean the increase in the average temperature of the atmosphere, oceans and landmass of the earth [9]. Environmental Researchers have reiterated that global warming is humanly induced. Its chief cause includes burning of fossil fuels such as coal, oil and natural gas by automobiles which continually releases carbon dioxide into the atmosphere. According to UNDP 2007/2008 Human Development Report [10], the world temperature has increased around 0.7ºC since the advent of industrialization and the rate is skyrocketing yearly. It is argued that, biofuel is environment friendly because carbon dioxide release from burning biofuels is balanced by carbon dioxide intake by growing plants from where biofuels are made [11]. This process reduces greenhouses gas emissions.

3.3 Market for Biodiesel - Nigeria

Currently no commercial biodiesel plant exists in Nigeria, except for a few largely undocumented production facilities. Production and consumption is still very low. With the global trend in the automobile industry, where there is now an increasing emphasis on renewable energy, biodiesel is becoming more and more popular. This global trend is paving the way for increased consumer confidence in automobile engines' ability to utilize biodiesel of which Nigeria cannot be isolated. With an estimated population of about 150 million people and a population growth rate of 2.38% (2007 estimate)

and an average of 12 vehicles to 1000 people(1997 estimate), the potentials of biodiesel cannot be underestimated in view of the continued epileptic power situation and the increase in the use of diesel generators by individuals and corporate organizations. In 2007 alone, fuel ethanol demanded was 1.3 billion litres, with anticipated increase of 2.0 billion litres in 2020. While biodiesel demands in 2007 was 480 million liters, with a projected demand of 900 million liters in 2020 [12]. Figure 1 further revealed groundnut and palm oil produce in Nigeria from 1999 to 2004. Groundnut production increases from 2.31 M(MT) in 1999 to 2.815 M(MT) in 2004. Palm oil produce also increases from 0.825 M(MT) in 1999 to 1.02 M(MT) in 2004. This revelation is a pointer that Nigeria is potent and poised for biodiesel production.

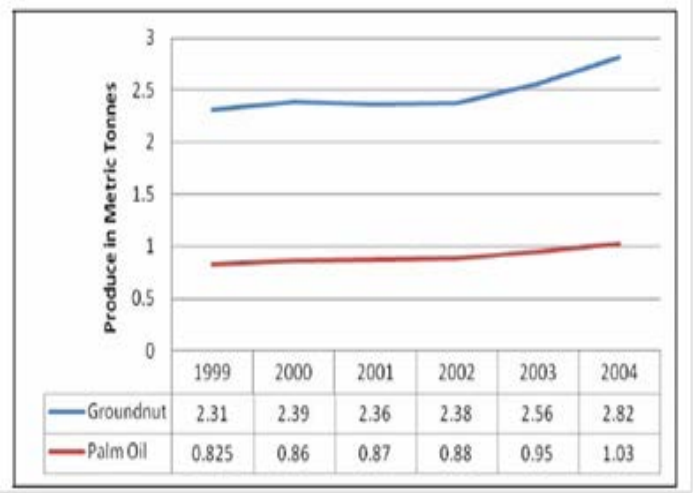

Fig.1: Production Showing Groundnut and Palm Oil (Source: [14])

Table 1: Market Demand Per Year for Different Energy Resources (Source: [11])

S/N		Market Demand per Year (litres)
1	Gasoline (E10 Blend) –current - 2020	1.2 billion 2 billion
2	Paraffin (Replacement With Ethanol Based cooking Gel Fuel)	3.75 billion
3	Raw Material for Portable Ethanol	90 million
	Total Market Size	**5.04 billion**
4	Current market possibility (E-20)	480 million
5	Estimated bio-diesel demand by 2020	900 million

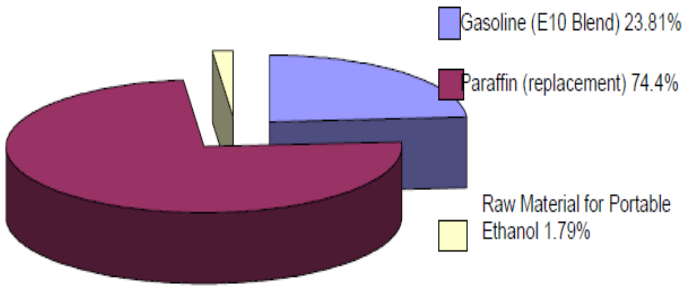

Fig.2: Distribution of Ethanol Utility (Source: [11])

3.1 Market for Biodiesel – International

Since the realisation of the need by world leaders to save the planet from further environmental degradation, there has been repeated emphasis on the reduction of harmful emissions into the atmosphere which has culminated in the adoption of the millennium development goals. Hence biotechnology which is renewable and environmentally friendly is been advocated as a viable alternative. With automobile industries designing cars that can run on biofuels, the market is definitely available and exports possible. Volkswagen for example has authorized the use of 5% bio diesel in all its cars. The consortium of US engine manufacturers (OEM) is currently testing the viability of a 20% blend in their diesel engines [13].

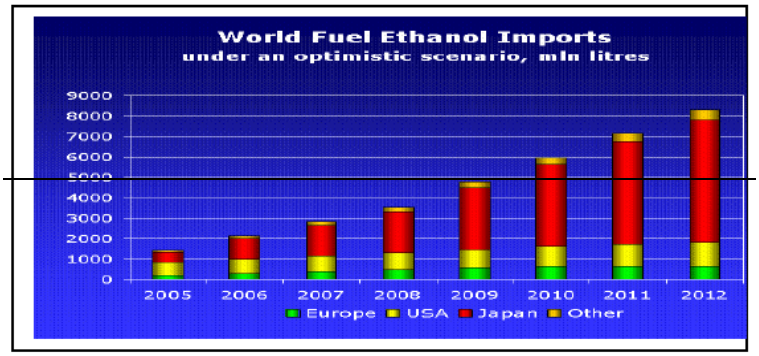

Fig.3: World Fuel Ethanol imports (source: [11])

4. THE BIODIESEL PRODUCTION PROCESS

The technology of converting vegetable oils and animal fats into bio diesel is a well-established process and very easy to be adopted in Southwest Nigeria [3]. The most commonly used and most economical process is called the *base catalyzed esterification of the fat with methanol*, typically referred to as "the methyl ester process". Essentially the process involves combining the fat/oil with methanol and sodium or potassium hydroxide. This process creates four main products - methyl ester (bio diesel), glycerine, feed quality fat and methanol that are recycled back through the system. The primary product, methyl ester, is better known as bio diesel. The glycerine and fats can be sold to generate added income from the process. The methyl ester process is very energy efficient in that for each unit of energy required by the process

approximately 3.2 units of energy are gained. Bio diesel is thus an excellent renewable fuel source. The ratio for ethanol production is 1.25. Bio diesel can be produced from any type of vegetable oil or animal fat. Some of the suitable feedstocks may require some pre-processing to remove materials that reduce the yield of bio diesel.

5. IMPACT OF BIODIESEL DEVELOPMENT ON NIGERIA'S RURAL ECONOMY

No doubt, there are great Opportunities of rising Demand on rural development.Building a new biodiesel facility in Southwest Nigeria will impact the economy on two levels: The new plant will generate output as it begins selling biodiesel and its by-products. These sales will, in turn, generate additional sales as the plant purchases inputs. The suppliers to the plant will increase the purchase of their inputs, thus increasing demand for those items. These increased sales will ripple through the economy. Jobs would have been created in the plant and also for suppliers of feedstock from across the country.

6. ENVIRONMENTAL IMPACTS OF BIODIESEL USE

Studies completed by the US Environmental Protection Agency (NREL/TP 2001) state that a 20% blend is "basically a trade-off between cost, emissions, weather, material compatibility and solvency issues". Researchers believe the 20% blend to be the best blend for general use without encountering major issues. Higher blends often cause problems with nitrogen oxide emissions [12].

Table 2: Emission Changes with Bio Diesel Fuel

Emission	100% bio diesel	20% blend*
Carbon Monoxide	- 43.2%	-12.6%
Hydrocarbons	-56.3%	-11%
Particulates	-55.4%	-18%
Nitrogen oxides	+5.84%	+1.2%
Air toxics	-60% to -90%	-12% to -20%
Mutagenicity	-80% to -90%	-20%
Carbon Dioxide**	-78.3%	-15.7%

* Average of data from 14 EPA FTP Heavy duty test cycle tests, variety of stock engines
** Life Cycle Emission

7. CONCLUSIONS

There exist a variety of potential feedstocks in Nigeria that could be utilized to produce bio diesel. These feedstocks vary significantly in price depending on supply and demand condition as well as market structural conditions. Feedstock costs would normally be between 50 and 75 percent of the cost of producing biodiesel and thus a reliable source of low priced feedstocks is critical to success. The processing technology for producing bio diesel is well established and presents little technological risk. The production of bio diesel is a very efficient process returning about 3.2 units of energy for each unit used in production. Bio diesel is thus an excellent renewable fuel source. It can be very easily integrated into the existing petroleum distribution system from the handling, chemical, physical and performance perspectives.

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