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# A SUSTAINABLE PROCESS FOR THE SYNERGY BETWEEN PETROLEUM AND BIOFUELS INDUSTRIES IN NIGERIA

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## ABSTRACT

Fossil fuels are globally consumed commodities and the world is facing acute peaking problems due to the ever increasing demand in the face of dwindling production rate and very serious environmental challenges. In Nigeria, the dependence on imported petroleum products for meeting local demands coupled with the instabilities in the centers of petroleum production has resulted in fluctuations in oil price and destabilizing the nation economies. Our near total reliance on petroleum to fuel transportation threatens our economy, causes devastating effects of climate change that threatens man's existence and poses a unique threat to our energy security. Combination of these factors has renewed the interest in finding alternate sustainable fuels such as biofuels to augment energy-security and at the same time maintain food security. Hence, this paper highlights the opportunities and challenges of a synergy between petroleum and biofuels industries in Nigeria for sustainable energy security. In conclusion, the paper recommends efficient policy implementation as a pathway of ensuring a sustainable petroleum and biofuels synergy, especially with large availability of arable land and varieties of bio-resources for biofuel production.

**Keywords:** Sustainability, Petroleum, Biofuels, Synergy, Nigeria

## INTRODUCTION

Crude oil and natural gas exploration and production has become a dominant sector of the world energy mix since the last century. In the Nigerian perspective, since the discovery of commercial reserves in the Olobiri of the former Bendel State in 1958, the sector has increasingly dominated the economy and displacing the agriculture and solid minerals (Odeyemi and Ogunseiten, 1985). Currently, these commodities accounted for over 90% of both foreign exchange benefits and total government revenues (Galadima *et al*., 2011). However, continuous reliance on only one sector is unsustainable, especially considering the fact the current proven reserves of 36.22 billion barrels and 181 trillion cubic feet of oil and gas respectively could only last for the next 35 to 40 years at current consumption rate. This could be attributed to the rapid increase in population and energy consumption and the associated development in science, technology and socio-economic activities (Enibe and Odukwe, 1990).

Also, in the wake of unending oil drilling catastrophes giving rise to massive destruction of the ecosystem, irresponsible onshore/offshore drilling practices, environmental concerns such as increased green house emissions (GHG), political instabilities within the oil producing regions, rising concerns over the continual availability of fossil fuels, fluctuating oil market, politics of oil trading within the Organisation of Petroleum Exporting Countries (OPEC), brain drain as a result of underemployment of Nigeria's university and polytechnic graduates, it has become exigent for Nigeria to join the rest of the world in the search for alternative and renewable energy resources especially for the transport sector. Biofuel provide that sustainable alternative. The exploitation of biofuels in Nigeria should however be done in such a way as the achieve synergy in a win –win scenario between the sectors.

## WHAT ARE BIOFUELS?

Biofuels can be defined as fuels produced from agricultural resources. They can be produced from agricultural and forest products and the biodegradable portion of industrial and municipal waste. The extensive range of agricultural products used for biofuel production as shown in **Figure 1** includes corn, wheat or sugar cane; rape seed, soya beans or jatropha; vegetable oils and animal fats. Biofuels are commonly referred to as first generation, mainly bioethanol and biodiesel, or second generation, which cover a variety of technologies currently in the pipeline. In the context of this paper, the word biofuels will focus on two main types of liquid biofuels produced from purpose-grown, land-based energy crops: bioethanol and biodiesel. Bioethanol is used as a substitute for gasoline and biodiesel is used as a replacement for diesel.

## BIOETHANOL

Ethanol or ethyl alcohol, is produced organically by natural fermentation of carbohydrates and starches contained in sugar beet/cane, potatoes, etc. Apart from its various uses, it has been an additive to petroleum (Agrol, Gasohol or Petrohol) since the 1930's and has been the mainstay of Brazil's transport system for over 20 years. It only takes three days to ferment a mash, after which the alcohol may be distilled out at reasonably low temperatures, thereby saving on the energy cost of production.

It takes over 3 litres of mash to make 1 litre of ethanol, and the by-product may then be used for cattle feed. Already a liquid at normal room temperatures, the form of energy is therefore more concentrated - about 5.7 kWh per litre, or half that of petrol. With no requirement for specialised on-vehicle storage facilities, this makes it a viable transport fuel without the associated pollution, as well as being able to use existing technology and refilling facilities. Cars running on Bioethanol, which is produced from agricultural crops, sugar cane or bio-mass, are governed by the same law of physics as those using gasoline. That means both emit $CO_2$, as an inevitable consequence of the combustion process. But there is a crucial difference: burning ethanol, in effect, recycles the $CO_2$ because it has already been removed from the atmosphere by photosynthesis plant during the natural growth process. In contrast, the use of gasoline or diesel injects into the atmosphere additional new quantities of $CO_2$ which have laid fixed underground in oil deposits for millions of years.

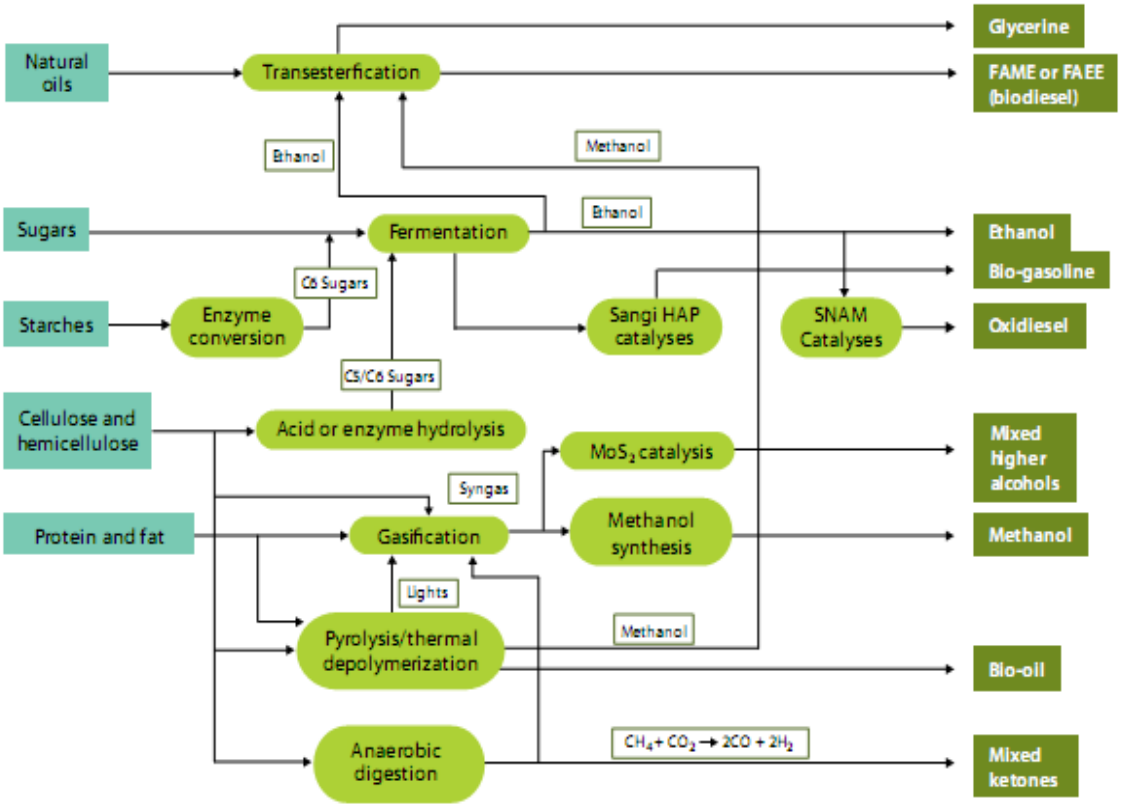


**Figure 1. Integrated technology pathways to produce biofuels (Pike *et al.* 2008)**

**BIODIESEL**

Biodiesel was probably the first of the alternative fuels to really become known to the public. The great advantage of biodiesel is that it can be used in existing vehicles with little or no adaptation necessary. Biodiesel is, naturally, a compromise for this reason, but still balances positively on the energy scales. There are energy plants available that will produce a higher yield in kWh per area, but the simplicity of having a fuel that is fully compatible with present fuel and engine technology makes it very attractive.

Biodiesel has several important advantages over conventional diesel as a power source for base stations. Biodiesel can be produced locally, creating employment in rural areas, while reducing the need for transportation, related logistics and security. Biodiesel has a much lower impact on the environment than conventional diesel. The cleaner burning fuel results in fewer site visits and also extends the life of the base station generator, reducing operator's costs.

The essential element of biodiesel is oil - animal or vegetable; used or recovered oil or tallow. Treated with alcohol and a catalyst, mixed for an hour then left to settle overnight, the result is a pure biodiesel fuel compatible with currently manufactured motor vehicle engines. That is a simplification of the transesterification process. The quantity of the produced oil will depend on local availability of the seed; the economics depends on the amount of raw oil produced per hectare. In round figures, one hectare of land should produce an average 3 tonnes of Jatropha seeds at 40% oil content. Pressed at a 90% extraction rate, this gives 1100kg of oil, which is treated with 150 kg of alcohol to give in excess of one tonne (1100 litres) of biodiesel and 120 kg of the valuable by-product glycerol. It requires around 15% energy input to produce the biodiesel - almost exactly the same as for petro-diesel extraction and refining.

Biodiesel is rated at almost 12kWh per litre (only 7.5% below that of fossil diesel), giving a yield of 13MW per hectare per annum. Added to this, the 2 tonnes of oil-bearing meal produced contains an estimated 4kWh of energy per kg, resulting in an energy yield of a further 8MW per hectare. The benefits of this sustainable fuel are tremendous:

Environmentally, for every tonne of biodiesel used to replace petro-diesel (i.e Automotive Gas Oil):

- three tonnes less carbon dioxide are liberated from storage in fossilised hydrocarbons - that's a saving of nearly a tonne of carbon emissions
- 180gms less sulphur oxides are produced; (virtually zero emission)
- 20kg less nitrous oxides are produced; (although NO2 emissions are increased by 5%)
- 50kg less carbon monoxide is produced;
- 40kg less particulates are produced. (Smoke - fossil diesel PM contains carcinogenic aromatic hydrocarbons - biodiesel emissions do not).
- In addition, the fuel is biodegradable - 98% within 21 days (fossil oil - 50%) - and does not have an offensive, choking smell when used.
- Economically, there are also huge advantages:
- utilisation of set-aside and under-utilised land by the agricultural sector will increase employment potential by one person per twenty hectares dedicated to energy crops;
- cropping takes place annually, reducing long-term investments;
- capital investment may be in small-scale production plant, to reduce transport costs;
- refinement of by-products can be centralised;
- annual crop residues, including the pressed seedcake, can be burnt throughout the year in local electricity generating plant;
- the use of existing distribution facilities.

**LAND AVAILABILITY FOR BIOFUEL IN NIGERIA**

Nigeria's size and land usage are presented in **Table 1.** There is huge potential for biofuel in Nigeria as can be seen from Table 1. Nigeria's total area is 92.4 million hectares out of which 79.4 million and 13.0 million hectares are occupied by land and water bodies respectively. Agricultural land occupies 71.9 million hectares ranking Nigeria one of the top biofuel potential countries in the world. This indicates a high potential for agricultural production, a considerable proportion of which can be applied as feedstock in biofuels manufacture.

**Table 1: Land used area in Nigeria**

| Nigeria | Percentage (%) | Quantity (Ha) |
|---|---|---|
| **A. Size** | | |
| Total area | 100 | 92.4 |
| Land area | 85.9 | 79.4 |
| Water bodies | 14.1 | 13.0 |
| **B. Land Use** | | |
| **Agriculture Land** | 77.8 | 71.9 |
| Arable cropland | 30.5 | 28.2 |
| Permanent cropland | 2.7 | 2.5 |
| Pasture land | 30.6 | 28.3 |
| Forest and woodland | 11.6 | 10.9 |
| Fadama | 2.2 | 2 |
| Other Land | 8.1 | 7.5 |

***Adopted from Ohimain (2010)***

Agricultural production, which is solely in rural areas, results in cassava, sugar cane, rice, maize, Jatropha seeds, and crop residue. In 2005, bio-energy reserves/potentials of Nigeria stood at: fuel wood 13,071,464 hectares, animal waste 61 million tonnes per year, crop residue 8.3 million tones (Dayo, 2008). Nigeria can conveniently engage in the production of biofuels given its cassava, sugar cane, rice, maize and sweet sorghum output. More so, cassava production, has witnessed a phenomenal increase from 35.98 million metric tonnes in 1999 to about 44.693 million tonnes in 2004, a 24% increase in five years. Per capita sugar consumption in Nigeria is estimated at 8kg per annum. In the year 2000 the total import of sugar was put at 750,000 tonnes per annum and growing at the rate of 7% (Bugaje and Mohammed, 2008). Presently, Nigeria's sugar needs are met 100% by imports. The already established, now idle, sugarcane plantations, totalling 64,000 hectares could be put to immediate use to produce cane for bioethanol production.

## BIOFUEL DEVELOPMENT IN NIGERIA

Though the traditional energy sources in Nigeria are predominantly combustible renewable fuels (Ngala *et al*., 2006), there is an increasing shift and adoption of the first and second generation biofuels. The first generation biofuels which include biodiesel, bioethanol and biogas (Bugaje and Mohammed, 2008) are sourced mainly from edibles sources or current food material such as maize, soyabean, sugarcane, cassava for ethanol or oil production which can also be used as energy sources after further processing. The second generation biofuels which are fuels sourced from mainly non-edible sources such as jatropha and algae (Bugaje and Mohammed, 2008). A range of first generation biofuels are already being produce at small scales in Nigeria. Ethanol production is part of the traditional livelihood systems in the Niger Delta area and extending to some part of the south western States. Various individual and public investment projects in first generation biofuels are taking up in various part of Nigeria. These investment projects are at various stages of implementation ranging from feasibility studies to refinery plant installation. Progress has been reported in the designing of biogas plants at the Usman Danfodiyo University where a biogas digester with 425 litres capacity adequate for household cooking energy need has been developed (Goering *et al*., 1982). Other experimental efforts are also ongoing at the University of Nigeria, Nsukka and at the Global Network for Environment and Economic Development Research (GNEEDER) in Ibadan.

Similarly, there has been research on biodiesel production since 2005 at the National Research Institute for Chemical Technology (NARICT), Zaria after various laboratory experiments by Research officers of the Institute. During the laboratory tests, various seeds oil was identified for use in biodiesel production. Initially edible oils were used which includes: groundnut and palm oil. However, due to crisis that could emanate as result of their usage as food, hence the research was geared towards using non-edible seed oils which includes: *Jatropha curcas*, rubber seed, neem seed, castor seed etc. During this period, Researchers within the Institute were trained on available technology at Delhi University of Technology, Delhi, India. The aftermath of this training was the design and fabrication of a batch reactor (NARICT AND Greenfield ltd. UK) producing 150 litres per batch/ 600 litres per day of biodiesel. The production process used homogeneous catalysis. There are plans to go continuous in production using novel reactors based on heterogeneous catalysis.

## NIGERIAN BIOFUEL POLICY AND INCENTIVES

In promoting biofuels, the government in 2005 gave the Automotive Biomass Program for Nigeria directive to the Nigerian National Petroleum Corporation (NNPC) to facilitate the adoption on biofuels and promote investment in the sector. This led to the birth of the Nigerian biofuel policy and incentives, a government whitepaper for promoting biofuels in Nigeria. The white paper provides a broad policy platform for promoting the adoption of biofuels and for fast tracking the investment in biofuels value chain from feedstock production to biofuel refining and distribution. It set a target of 10 years for attaining full E-10 blending of gasoline and B-10 for diesel. Though the whitepaper identified very few source of biofuels feedstock in Nigeria particularly for producing first generation biofuels, Nigeria has the potential of producing feedstocks for second generation biofuels including jatropha, algae and Shea nut. The underlining objectives for government interest in a national biofuel promotion are among others revenue diversification, job creation, improving agricultural productivity, meeting energy needs as well as deriving environmental benefits.

**THE NEED FOR SYNERGY BETWEEN PETROLEUM AND BIOFUELS INDUSTRY IN NIGERIA**

With high oil prices, countries must develop counter policies to mitigate this effect on their economies. The most effective policy in this regard is energy diversification and for oil biofuels come as the first choice. In fact, biofuels could be the biggest single economic opportunity in terms of economic growth, poverty eradication and achieving MDG initiative. In this sense, biofuels should take priority in Nigeria's hydrocarbons policy with aims to stimulate economic growth, create a large number of new jobs and reduce poverty by 2015.

Oil giants in Nigeria should invest heavily in biofuels development and must develop national biofuels strategy in their soonest. Such strategies may enforce mandatory biofuels blending regimes on operating oil companies and allow the development of 100% biofuel supply and distribution systems. Flexible policies and regulations should also be enacted to help independent biofuels producers to implement various projects to produce ethanol and biodiesel to support the growing market demand for cleaner and cheaper liquid fuels. Biofuels such as bioethanol and biodiesel have been touted as the future of energy. Cleaner, home-grown and potentially cheaper than petroleum, countries such as Brazil and Britain have already made biofuels a major part of their energy consumption with many others expected to follow.

Biofuels are a complementary and alternative energy source to fossil fuels and they can contribute to:

- Supporting energy diversification and effective substitute to fossil fuel products;
- Strengthening national accounts by reducing high bills for imported petroleum products;
- Further increasing agricultural efficiency;
- Creating new job opportunities in agriculture, industry, infrastructure and science;
- Reduction of green house gas emissions and to better environmental conditions for all people on our planet; and
- Economic independence and prosperity for African countries and their citizens.

**THE ECONOMIC AND ENVIRONMENTAL ADVANTAGES OF PETROLEUM AND BIOFUELS SYNERGY**

Bioethanol can be blended with conventional fuels and used as additive to boost the octane number of unleaded PMS. Such a process will save considerable cost on the import of crude oil and oil products. Some references indicated that biofuels production in Africa could be profitable, even at an oil price below $50/barrel and suggested that bioethanol production would be the best hedge that Africa can have against high oil prices. Experts believe that even at sharp rise in the prices of crops used for biofuels industry, the government should keep the bioethanol industry operating, as it is a viable insurance policy against high oil prices.

Besides acting as a natural hedge to cushion the effects of the oil price on the economy, the large-scale production of biofuels in Nigeria could also provides several other economic benefits, probably the most important is job creation at a lower cost than in most other industries. South Africa estimates that the production of biofuels will create 100 times more jobs than oil refining. For instance, it is expected that the establishment of every ethanol plant will result in up to 10,000 direct and indirect jobs. Moreover, most jobs will go to people in the rural areas where the biofuel plants will likely be situated, thereby boosting rural economies and stemming migration to urban areas.

On the other hand, careful planning and investment in bioethanol industry could lead to a new revolution in agricultural development with double aim at securing food and energy at the same time. Small farmers and population living under poverty, in particular, will be the first to benefit. Small-scale farmers could potentially supply huge amounts of crops required as feedstock for biofuels plants. Therefore, this industry would support those small-scale farmers with detailed grower plans, better seeds, budgets and cash flows, financing and mentorship. This will eventually achieve sustainability. The biofuels plants could also develop outgrowers or contract farmers to grow crops exclusively for the company including flexible options which make provision for the participation of as many suppliers as possible. Since the price grading would depend on the fermentable-starch grading of the crop, farmers could be assisted to select the best varieties to plant which will result in increased production and hence increased cash generation. However, cautious must be observed as some critics have repeatedly pointed out that biofuels could simply push up the costs of crop plants and simply shift dependency rather than deal with it. Nevertheless, a coherent and well established biofuels strategy would lead to the creation of a value chain out of the use of biodiesel and bioethanol fuel products. That would result in significant job creation opportunities throughout such value chain. Most created jobs could be realised in the second economy, which would assist governments in meeting the MDG's objectives of bridging the gap between the first and the second economies and reducing poverty and unemployment by 2015. Apart from the benefits of job creation and economic growth, biofuels could be seen as an important move towards greater protection from uncertainty around high oil prices, and the use of biofuels is also likely to be less damaging to the environment. Many African countries depend on oil products which have severe economic implications in terms of balance of payments as well as vulnerability to rising crude oil prices. Increasing the volumes of ethanol in petrol and increasing the use of biodiesel would therefore have macro economic benefits for these countries. Such an energy strategy should be drafted to carry wider implications for the social and transformation and reduction in poverty. In addition, converting subsistence farmers into cash crop producers to supply the crops or inputs into biofuel will start to address the high level of unemployment problem, particularly in rural areas.

Another economic benefit of biofuels production is the sale of carbon credits under the Kyoto Protocol. Biofuels producing countries would benefit from this scheme of carbon-credits to get cash rewards. It was estimated that one liter of bioethanol produces half the greenhouse-gas emission of a liter of conventional petrol. Hence, the production and use of biofuels could assist participating Africa countries to earn valuable carbon credits by reducing greenhouse-gas emissions.

**CHALLENGES OF BIOFUELS PRODUCTION**

Nigeria, nay Africa, can afford to convert sugarcane nor corn to biofuel for such common reasons such as the widely debated food versus fuel campaign which simply means that it will be inhuman to channel food to the production of fuel when the vast majority of the populace are nearly feeding from dustbins. Other environmental impacts are the expensive irrigation practices and the pressure on land use. Extremely weak research activities to generate the best strains of crops taking the least time from germination to maturation as well as having desirable traits to make the entire process profitable. Another issue is the poor management style as exemplified in almost every facet of the Nigerian life, this is one singular factor militating

against us in the quest for total self reliance. Having mentioned all these drawbacks, shall we rend our clothes and pour ash on our heads in defeat? The answer is NO. There is an upheaval in the pursuit of biofuel production using agricultural, industrial and municipal wastes as primary substrates. Corn stover, crop straws, sugarcane bagasse, herbaceous crops (alfalfa, switch grass), short rotation woody crops, forestry residues, waste paper and other wastes (municipal and industrial) are currently used in the quest for sustainable biofuel production. Currently the production volume is a little above 30 billion litres and climbing, this represents about 2% of the total gasoline usage worldwide.

**CONCLUSION AND RECOMMENDATIONS**

Nigeria has all that it takes to research extensively into biofuel production and by this I mean starting with the two most promising biofuel - Bioethanol and Biodiesel. Our government must think futuristic here, our oil reserve may not last forever and even if it will, once the biofuel production is optimized in leading research countries, our earning capabilities might be greatly hampered. This would be another catastrophe for the economy. It is left for the government to design and implement a sustainable biofuel production programme employing the services of skilled professionals in the industries faculties of various higher institutions in several disciplines and the armies of students (from undergraduate to doctoral candidates) to work on the research.

In order for Nigeria to establish strategies for petroleum-biofuels industries synergy programs the following guidelines might be of help:

- The first step is to establish a task team to develop the appropriate strategy for biofuel production within determined timeframe.
- Such task team should be composed of government, public and private sectors, such as representatives from the Ministry of Petroleum Resources, Ministries of Agriculture, Water and Forestry, Science and Technology, Trade and Industry, Transport etc.
- Key activities to be undertaken by the task team would include: identification of resource requirements (land, crops, incentives, human capital, etc); feasibility studies for plant construction; long term feedstock supply contracts, farmer outreach activities; cost-benefit analyses to determine optimal use of land, water, etc; how to move farmers from subsistence farming to commercial crop farming, including what support they might need such as in agricultural extension services and advanced farming methods; dealing with issues such as land tenure, reform and usage and, finally, protecting vulnerable participants, such as farmers, from food price volatility, oil price drops and currency fluctuation.
- Consultative forums should also be established to support the task team. These could be made up of Science Councils, higher education institutions and industry specialists on the technical side.
- On the commercial side, relevant institutions such as state-owned enterprises, industry players and business associations should heavily be involved.
- The project team should establish close associations with international players who are active in this industry.

Finally, it is obvious that the petroleum and biofuel industries could both benefit immensely from synergy between them to enhance sustainable development.

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