CURRENT STRIDES IN BIOENERGY AND BIOFUELS TECHNOLOGY DEVELOPMENT IN NIGERIA

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1. Abstract

This paper examines Current Strides in the area of Bio-energy and Bio-fuels Technology Development in Nigeria. Nigeria, which occupies a total land area of more than 92 million hectares, has adequate potential for biomass production. The arable land is about 30 million hectares. Even though the agricultural policy of Nigeria is tilted towards food production, biomass agriculture can have a very significant, positive influence on the national economy. Energy crops represent, the largest potential source of bio-energy feed-stocks, whether as whole biomass, wastes or residues. Nigeria shares the concern in the global discussion on the competition between land- use for food-and-feed production and bio-fuels production. However, there is an abundance of energy crops. An example is jatropha *curcas* that grows on marginal land, and produces oil-bearing seeds that are not suitable for human consumption. The Nigerian Government is creating awareness on the potential of jatropha oil as feed-stock for the production of biodiesel, and encouraging local farmers to plant the crop. Recognizing the fact that there is a dearth of conversion technologies for feed-stocks to biodiesel product, the Petroleum Technology Development Fund (PTDF), an Agency of the Federal Government of Nigeria, has endowed a Professorial Chair in Renewable Energy in the University of Benin, Benin City, Nigeria. The Chair, which is domiciled in the Department of Chemical Engineering, is to focus its research on the "Development of a viable technology for the production of biodiesel from oils of non-edible seeds"

2. Introduction

Energy is the mainstay of Nigeria's economic growth and development. Nigeria's energy production is mainly from petroleum. Most of the vehicles are run on diesel fuel and much of the electricity used in buildings, homes and plants is produced with generators running on diesel fuel. This creates a major problem in Nigeria due to the fact that without diesel, the country is very inefficient. As is well established by now, bio-fuels may offer advantages to developing countries. These countries can 'leap frog' into greener world that is based on a new energy and developing paradigm. Bio-fuels bring a reduction of dependence on oil and the high fossil fuel prices that are so detrimental to their economies. They offer increased energy security through fuel diversification, income generation for farmers and rural communities, new jobs in wide range of sectors, decreased air pollution and green house gas emission.

Ultimately, bio-fuels hold the potential to include some of the world's poorest people into the wider economy looking at them as energy producers, especially in Nigeria, where more than 70% of the populace make a living from agriculture. Social inclusion and income generation on a massive scale through bio-fuels can lead to lower pressure on the environment, strengthened lively hood and to more sustainable developments. According to Kupolokun, a erstwhile Group Managing Director of the Nigerian National Petroleum Corporation (NNPC), Nigeria introduced bio-fuels into the nation's energy mix, despite being an OPEC member and African continents' largest oil producer because 'the integration of the agricultural sector with the energy sector opens a new world of opportunities to all members of society'. Speaking at the 18th Enugu International Trade Fair, he shed light on a US $350m Nigerian Content Support Fund (NCSF) which has created an avenue, through which indigenous companies could source bio-fuel fund to compete with their foreign counterparts and to strengthen Nigeria's grip over its non-energy supplies. Even though Nigeria is a crude oil producer, the refined fuels sold in the country are under control of foreign capital. Nigeria wants to change this situation. Moreover bio-fuels production on the other hand is based on distributed production of feed-stocks amongst many different farmers and is based on local instead of foreign labour.

Energy, and in particular, oil and gas, have continued to contribute over 70% of Nigeria's Federal revenue (Sambo, A.S 2009). However, the environmental problems of petroleum exploration have bred discontent in the Niger Delta region of Nigeria, the home of crude oil prospecting. With the rest of the developed world seeking alternatives to petroleum products for transportation or power generation and heating, sooner or later, the developing nations may find that they have been left behind technologically. The need to develop alternatives to petroleum oil can, therefore, not be over emphasized, considering the fact that petroleum is very vital for the transportation and power needs of a nation. Consequently the Federal Government of Nigeria (FGN) has produced policy guidelines for the take-off of the bio-fuels industry in Nigeria.

3. Nigerian Bio-fuels Policy

The Federal Government of Nigeria, (FGN), directive of August, 2005 on an Automotive Biomass Programme for Nigeria, mandated the Nigeria National Petroleum Corporation (NNPC) to create an environment for the take-off of a domestic fuel ethanol industry. The primary objective is to reduce dependence on imported gasoline, reduce environmental pollution and create a viable industry for sustainable employment generation.

The policy envisions the introduction of environmentally-friendly fuel that impacts significantly on the enhancement of petroleum production quality to reduce the current limitations of fossil-based fuels.

The Nigerian Bio-fuel Policy defines bio-fuels as fuel ethanol and biodiesel, and other fuels made from biomass, and primarily used for automotive, thermal and power generation, according to quality specifications of the Standards Organization of Nigeria (SON), Department of Petroleum Resources (DPR), and any other competent government agency. It has also defined biomass to mean agriculturally produced raw materials which are available on a renewable or recurring basis, including trees, crops, plant fibre, cellulose-based materials, industrial waste, and the biodegradable component of municipal solid waste.

The policy defines biodiesel as meaning fatty acid methyl ester or mono-alkyl esters derived from vegetable oil or animal fats for use in diesel engines, according to quality specifications of SON, DPR and any other competent government agency or authority.

Cassava, sugar cane, oil palm, *jatropha*, cellulose-based materials and any other crop as may be approved by the Bio-fuel Energy Commission qualify for production in Nigeria as bio-fuels feedstock. Thus the programme has potential for the poor Nigerian farmers who make a living from agriculture, to enhance their income generation, among other agricultural benefits.

Programme implementation.

The programme is to be implemented in two phases. Phase one involves the blending of up to 10% of fuel ethanol with gasoline to achieve an E-10 blend, with imported fuel ethanol. Importation will continue until a time when sufficient capacity and capability for large- scale production of the bio-fuel feedstock and establishment of bio-fuel plants would have been developed in Nigeria.

Phase two takes off concurrently with phase one with the establishment of plantations and the construction of bio-fuels distilleries and plants. As at when the policy was gazetted in July 2007, it was estimated that for E-10 blend, about 1.3 billion litres of ethanol would be required. The quantity was estimated to increase to about 2 billion litres by 2020. In the case of biodiesel, based on the 2007 demand for a 20% blend, 480 million litres of ethanol were required. Again the quantity was estimated to increase to about 900 million litres by 2020, when domestic production of biofuels consumed in Nigeria would have hit 100%.

Policy Objectives

The main objective is to establish firmly a thriving fuel ethanol industry which uses agricultural products for the improvement of the quality of automotive fossil-based fuels in Nigeria. The agricultural and energy sectors are thus linked to stimulate development in the agricultural sector.

There are no major ethanol production plants currently; some artisanal producers of ethanol exist. Government of Nigeria is currently promoting the planting of cassava (*manihot esculenta*) to serve as feedstock for ethanol production even though cassava and its derivatives are consumed as food in Nigeria.

Broadly, the policy is aimed at:

- promoting job creation, rural and agricultural development and technology acquisition and transfer;
- providing a framework capable of attracting foreign investment in the bio-fuels industry.
- streamlining the roles of the various tiers of government to ensure an orderly development of the bio-fuels industry in Nigeria, and
- involving the oil and gas industry in a more purposeful development of other sectors of the economy of Nigeria.

The Nigerian Bio-fuels policy has set the stage for achieving the primary and broad objectives by making provisions for:

- the establishment of :
  - Bio-fuels Energy Commission with the responsibility to implement the strategies for bio-fuels in Nigeria.
  - Bio-fuels Research Agency to act as the central coordinating body for bio-fuels research in Nigeria.
- funding of research, and development to encourage participation of both the private and public sectors in research and development.
  - bio-fuel companies to contribute 0.25% of their revenue for funding research into feed-stock production, local technology development and improved farming practices,
  - FGN to contribute up to 100% of total contribution by bio-fuels companies;
- requiring the Petroleum Technology Development Fund (PTDF), that was established under the Petroleum Training and Development Fund Act to also fund research and development in bio-fuels; and,
- making all expenditure on research and development by bio-fuels companies fully tax deductible.
- Incentives
  - bio-fuels projects are eligible for pioneer-status-tax holiday within the provisions of the Industrial Development (Income Tax Relief) Act;

- exemption from withholding tax, and capital gains tax under some sectors of the company Income Tax Act;
- waiver on import and export duties, amongst others.

Collaborative efforts

Government while seeking collaboration with UNIDO, is also encouraging research into bio-energy and bio-fuels development in Nigerian universities and research institutes. Consequently, Government is encouraging research into renewable energy in all its ramifications, by setting up eight research institutes/directorates to handle the different areas. The National Centre for Energy and Environment, situated at the University of Benin, to serve the South-South Geopolitical region of Nigeria, is to provide a platform for development of conceptual and operational policy framework for sustainable biomass energy production/technology transfer, organize and conduct research and development R&D programmes in bio-energy and environment. It is to make renewable energy sources mainstream resource through research and development initiatives in bio-energy production and environmental forensics/ management. It is to promote the sustainability of renewable energy and development programmes, develop and execute pilot projects highlighting the potentials of bio-fuels production and waste-to-energy programmes, as well as monitor R&D activities in bio-energy production.

In addition, Petroleum Technology Development Fund (PTDF), an Agency of the Federal Government of Nigeria, as provided for, in the Nigerian Bio-fuels Policy, has endowed renewable energy Chairs in some Nigerian Universities. The Chair in the University of Benin is to research into the Development of Bio-energy and Bio-fuels Technology with emphasis on the Development of a viable technology for the production of biodiesel from oils extracted from non-edible seeds.

4. Why Biodiesel?

In Nigeria, petroleum products are primarily used for transportation for powering spark-ignition engines and, compression-ignition (diesel) engines. Biodiesel is seen as an alternative to petro-diesel for compression-ignition engines, even though it has a lower energy density than petro-diesel. It has a greater lubricity and higher cetane number and hence a more complete combustion quality.

Biodiesel can be used in existing modern diesel engines without modification and can be blended with petro-diesel in any ratio, wholly or partly. Its use results in the net reduction in CO_2 emissions. It can be produced from virgin vegetable oil, waste cooking oil, animal oil and fats, and oil from algae. However, the different types of oils must first be sourced through local biomass production.

Local Biomass Production

Nigeria occupies a total land area of 92, 337,000 ha (923,370 km^2) (Holm-Nielsen et al, 2006), distributed as follows:

- Arable land ----------30,200,000 ha
- Permanent crops----------2,800,000ha
- Permanent pasture------39,200,000ha
- Forest and wood lands--14,300,000ha
- Others----------5,837,000ha

There is thus no doubt that Nigeria has adequate potential for biomass production, especially for oil seed crops. However, there is the concern that a large-scale development of resource for biodiesel production will negatively impact on arable lands used for cultivating food crops. Consequently non-edible oil seed crops which can thrive on marginal land are favored.

According to Oderinde et al (2009), Nigeria has one of the most extensive *flora* in continental Africa. As a tropical country, Nigeria has a wide variety of domestic plants that produce oil-bearing materials of sufficient volume potential eg. Neem (*Azadirachta indica*) and the physic nut (*Jatropha curcas*) considered as feed stock for biodiesel production. Unfortunately, the vast majority of the seed oils have not been adequately characterized. Examples include *hura crepitans*, otherwise known as sand box tree, neem, castor, etc. Of those oil seeds already tested, *Jatropha curcas* and neem (*Azadiracta indica*) already thrive in Nigeria. Using

the non-edible oil of *jatropha* has the potential to make the process of biodiesel production economically feasible.

Plants use photosynthesis to convert solar energy into chemical energy which is stored as proteins, oils, carbohydrates etc. Emphasis should therefore be tilted towards cultivating those plants that produce seeds with very high oil content.

Jatropha, is a perennial shrub. Even though it is doubtful that *jatropha* would be grown at such a level that it would provide adequate oil feed-stock for biodiesel as an alternative to petrol-diesel the Nigerian Government has encouraged the formation of an Association of Jatropha Farmers to grow the crop in the Country. Small-holder farmers are the major beneficiaries of the scheme.

Hura crepitans is of interest considering its high level of oleic acid (18:1) in the oil. Cotton thrives in Northern Region of Nigeria. However the oil is edible. Castor (*Ricinus comunis L.*) has viable possibilities because it is an annual crop whose cultivation allows farmers to practice crop rotation. The Nigerian variety of castor seed has an oil yield of 44.7% on extraction (Orbih, O.A 2011). Castor survives under warm and humid tropical conditions and it matures in about 5 to 6 months. The average seed and oil yields are about 1150kg/hectare, and 500 litres per hectare, respectively. Castor plant has a shorter growing period than *Jatropha.* It is an annual crop. Large-scale cultivation of castor appears to provide a better option of non-edible oil seed crop for sustained biodiesel production.

Thus, there is the possibility of dedicating about 1,000,000 hectares of the 'other land area' in Nigeria for planting non-edible seeds oils.

Although, in the agricultural policy of Nigeria, priority is food production, there is growing awareness that energy crops have to be planted to feed the energy bio-fuels industry. Efforts are on to explore the full potentials of suitable oil seeds that hitherto had not been tested, for biodiesel production.

Technology for processing the oil-feedstock into biodiesel

Nigeria is in the early phase of commencement of biodiesel projects development. There is a dearth of competitive conversion technologies in the country. At the moment only simple process technologies are being experimented. Examples include batch alkali or acid catalyzed transesterificaton experiments. The alkali process can achieve high purity and yield of biodiesel product in a short time (El Diwani et al.,2009, Dorado et al., 2004, Meher et al., 2006a; Tiwari et al., 2007). Biodiesel produced by transesterification reaction can be catalyzed with alkali, acid, or enzymes. Chemical catalyst processes, including alkali and acid ones are more practical compared with the enzymatic method.

Hence the Chair in the University of Benin is studying the development of biodiesel process using *jatropha* oil as feedstock with methanol and sodium hydroxide as the catalyst, and evaluation of the biodiesel as a fuel.

Biodiesel production in the bio-fuels sector

In transportation the renewable energy source is bio-fuel. Globally, the transport sector consumes about 40% of fossil energy resources, making bio-fuel development an attractive alternative to conventional petro-fuel (Montrimaite, 2010). One of the tasks of renewable research development is to increase the use of renewable and other sources (wasting) in transport ensuring such that their production and application all over the world should have a positive effect on the environment.

5 Biogas production

Biogas production is being intensified in northern Nigeria given the concentration of livestock in that part of Nigeria. The Sokoto Energy Research Centre has over 21 Biogas plants, 10-20m^3 capacities. The Raw Materials Research and Development Council funded construction of a biogas plant in University of Agriculture, Makurdi in 1999. UNDP successfully introduced the floating drums, plastic balloons etc to Yobe, Kano and Jigawa States of Nigeria under the Africa 2000 Low Technology Biogas System. The UNDP has introduced the technology to some abattoirs in some northern states of Nigeria. The bank of Industry (BOI) in collaboration with the United Nations Development Programme (UNDP) has just signed an agreement for a $4.48million alternative energy partnership called Access to Renewable Energy project.

The project will start with a take-off capital of $655,000 with the UNDP expected to provide #2million initial capital. The BOI will be responsible for implementing the project and will also house the project management unit (Vanguard, 2011).

Private Initiative in Nigeria

Some private companies are entering into partnership agreements with some state governments to produce agricultural feed-stocks for bio-diesel production. The minimum land size is 10,000 ha. One company plans to establish a 100,000 litres/day bio-diesel plant. Given FGN's incentives, more companies will show interest in investing in the bio-fuels industry in Nigeria.

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6. Conclusion

Nigeria has recognized the need to develop its bio-fuels industry and has taken adequate steps towards its realization by formulating her bio-fuels policy. It is no gainsaying that Nigeria is rich in farmland that can sustain biomass production for the bio-fuels industry, and has some of the best arable lands to farm in the world. Government is now working closely with the NNPC to implement "clean energy" projects around the country, and in collaboration with private companies. Also government, through its agencies, is funding research in bio-energy and bio-fuels technology in Nigerian universities and research institutes. The government is now looking at implementing new legislature on blending biodiesel with any diesel that is being used, for commercial purposes with a view to solving its current energy crisis and going more environment-friendly for the future.

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