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Research and Development Potentials in Biofuel Production in Nigeria (Pp. 34-45)

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Abstract
Nigeria is at present suffering from the worst energy crisis in her 48 years of existence as an independent nation. Even though there is a global crisis in the international oil market, Nigeria seems to suffer disproportionately from the negative impacts when compared to other oil producing nations. Although, Nigeria's natural resource wealth (including renewable energy potentials) has been well documented and acknowledged, the contribution of renewable energy sources to the total national energy supply and demand is currently very low or negligible. There is a clear link between access to energy services and poverty reduction and hence development. Apart from its contribution to poverty reduction, it is the very diversity of biofuel that provides potential of a win-win development path for the environment, social and economic development, and energy security. It is in the light of this that this paper examines the research and development potentials in ethanol and biofuel in Nigeria.

Keywords: *Biofuel; Energy; Oil; Poverty reduction; Development*

Introduction
Irrespective of Nigeria's position as the sixth largest petroleum oil exporter and a leading gas exporter, the nation suffers enormous energy crisis

manifesting in various forms. Thus, about 60 -70 % of Nigerians (presently more than 140 million) are excluded from the national electricity grid which is plagued by rather frequent power outages that last for as long as about 20 hours daily in places that are connected to the grid.

Although, Nigeria's natural resource wealth (including renewable energy potentials) has been well documented and acknowledged, the contribution of renewable energy sources to the total national energy supply and demand is currently very low or negligible. Gas usually flared during petroleum refining accounts for Nigeria's contribution of as large as 4.0 percent to the global Green House Gas (GHG) emission (NNPC, 2005). The use of fossil fuels by a large proportion of the population for public automobile transport, domestic cooking, lighting and so forth also aggravates existing ecological degradation.

Since the energy crisis of the 1970s, developing new energy sources from the agricultural sector has been viewed as a way to expand the domestic energy supply and help mitigate growing dependence on imported oil in many developing and developed countries. For instance, including hydropower, renewable energy accounted for 6.0 percent of United States energy consumption in 2004, with energy from biomass contributing almost half of that total. Biomass energy is primarily produced from wood (70 percent) followed by waste (20 percent) and alcohol fuels (10 percent). While wood has provided most of the biomass energy over the years, ethanol has been the fastest growing renewable energy source over the past 10 years. Ten years ago, ethanol's share of biomass energy was less than 4.0 percent (Ashworth, 2002).

Biofuel have the potential to deliver a number of benefits including reduction of greenhouse gas emissions, improved air quality and increased energy security. However, the production of biofuel is currently expensive, especially those for transport applications. It is in the light of this that this paper examines the research and development potentials in ethanol and biofuel in Nigeria.

Exploring the Linkage between Biofuel, Economic Growth and Development

Modern biomass energy services have the potential to make a significant contribution to a new energy paradigm. The world currently consumes about

400 EJ (exajoules) of energy per year but generates the equivalent of about 100 EJ of largely unused crop residues. It could produce an additional 180 EJ from energy-dedicated grasses and trees. Despite this potential, bioenergy must be viewed not as the single replacement for oil, but as one element in a wider portfolio of renewable sources of energy (Ashworth, 2002).

The production of energy from biomass involves a range of technologies that include solid combustion, gasification, and fermentation. These technologies produce liquid and gas fuels from a diverse of biological resources—traditional crops (sugarcane, maize, oilseeds), crop residues and waste (maize stover, wheat straw, rice hulls, cotton waste), energy-dedicated crops (grasses and trees), the organic component of urban waste. The outcomes are bioenergy products that provide multiple energy services such as cooking fuels, heat, electricity, and transportation fuels. It is this very diversity that provides potential of a win-win development path for the environment, social and economic development, and energy security (European Union, 2006).

There is a clear link between access to energy services and poverty alleviation and hence development. The first sets of critical energy needs are those that satisfy basic human needs: fuel for cooking, heating lighting, energy for pumping water, and electricity for health education services. The second sets of critical energy needs are those that provide energy for income-generating activities that help cycle of poverty.

The poor rely heavily on biomass as a source of energy. However, traditional bioenergy which is derived mainly from the combustion of wood agricultural residues has severe negative impacts in the following forms. First, when combusted in confined spaces, these substances produce significant indoor pollution to which women and children are primarily exposed. Exposure has severe health consequences, including respiratory illnesses and premature death. Second, this kind of biomass use immense pressure on local natural resources, especially as communities must satisfy increasing demands for energy services.

Local benefits, especially for the poor, can be enhanced by organizing small-scale producers to meet the output volume and reliability needs of conversion facilities. In Brazil and the United States, large corporations dominate the bioenergy industry, but farmer cooperatives play a useful role in linking these large firms to independent growers (Osterkorn, 2006). Similar arrangements may be needed in other countries including Nigeria if the industry is not to develop in a vertically integrated way with only large-scale growing of biomass feedstocks.

A key motivation in the development of biofuels is the possibility of diversifying energy resources and displacing large oil import bills with spending on locally produced biofuels which will generate increased employment opportunities and output (NNPC, 2005). But the opportunities for rural development should also be a key priority. Rural development benefits from a dynamic bioenergy sector, beginning with feedstock production. Because agricultural production in many developing countries is characterized by labor-intensive activity, additional demand for agricultural products will increase employment and wages in the agricultural sector. Furthermore, the additional personal income generated has the potential to induce significant multiplier effects as it is spent by the rural population.

Bioenergy could make multiple contributions to the fight to eradicate poverty and improve food security. In developed countries, shifting land use toward biomass for energy would reduce dumping in the commodity markets and give farmers in developing-countries access to higher prices. In developing countries, the production of energy in concert with sustainable food production and the sustainable use of local resources could also result in higher incomes for farmers and added energy services for the community. All of these would enhance the community's ability to develop economic activity designed to reduce poverty and enhance food security.

Current Development in Biofuel and Ethanol Market: Local and International Perspectives

In 2000, about 1.6 billion gallons of ethanol was produced in the United States. By 2005, about 4 billion gallons of ethanol was produced, a 150 percent increase in 5 years. In 2006, nearly 5 billion gallons of ethanol is to be produced a one-year increase of 20 percent. In the United States there are now 101 ethanol plants with total capacity of 4.8 billion gallons operating in 20 States (Osterkorn, 2006). The Renewable Fuels Association reports that there are 39 ethanol plants under construction and another 7 facilities expanding with total capacity of 2.6 billion gallons per year. On the completion of the construction and expansion activities, ethanol capacity in the United States is expected to be 7.4 billion gallons per year (Ashworth, 2002).

A number of factors have contributed to the rapid increase in production in the United States. These include the 51 cent per gallon tax credit provided to blenders, high and volatile oil prices, low corn prices, the Renewable Fuels Standard (RFS) under the Energy Policy Act of 2005, and the elimination of ethanol's main oxygenate competitor, methyl tertiary butyl ether (MTBE) (see www1.eere.energy.gov/biomass/pdfs/po32121.pdf)

Another factor supporting ethanol expansion has generally been the improving production economics. Ethanol production costs declined between 1980 and 1998. Thus technology improvement over this period has resulted into: (1) a higher yield of ethanol per bushel of corn, (2) a lower cost of enzymes required for conversion, and (3) production automation which lowered labor costs. Energy input costs also fell over this period. Department of Agriculture (USDA) surveys indicate that between 1998 and 2002 the average cost of producing ethanol (excluding capital costs) remained unchanged at about 95 cents per gallon. In 2002, higher energy costs were offset by lower labor and enzymes costs. Since 2002, the cost of production has increased by 10 to 15 cents per gallon due to the increased cost of energy (electricity and natural gas). Hence, USDA estimates that the current average cost of ethanol production is about $1.10 per gallon.

Brazil's successful development of an ethanol-based biofuels sector since the 1980s, hardly noticed at first, has been the envy of other countries more dependent on oil imports. The government had the foresight to notice, long before the oil paradigm started to shift toward peak production, that its vast hectares of sugarcane could be put to good use as an ethanol source (Osterkorn, 2006). Hence, it granted heavy subsidies to agricultural and related industries to alter the source of transport fuels.

Experiences over the years suggest that small and medium scale plants for starch and flour (10 – 100 tonnes per day input) and ethanol (1000 – 100001 tonnes per day output) would be most appropriate rather than large-scale plants. This is the size of plants that can be supported sustainably by local agricultural systems in Nigeria. It follows that for Nigeria to meet its domestic demand for cassava starch, we may need at least 15 – 17 starch plants of 1000 capacity each. A 1000 cassava starch plant can support employment for at least 300 persons along the commodity chain (Osterkorn, 2006). Similarly, for Nigeria to meet its national demand for ethanol (ENA) it needs about 120 small scale (50001/day capacity) plants. One plant of this size will be able to provide employment for at least 400 to 500 persons along the commodity chain in one year of 300 days. At the moment Thailand is repositioning itself to compete in the international ethanol market. International interest in ethanol production is driven by demand for bio fuels. Many countries are currently pressurized by the Kyoto Protocol to reduce consumption of fossil fuel (Osterkorn, 2006, NNPC, 2005). Since Nigeria is a fuel producing country, it can only save foreign exchange by emphasizing domestic production of ethanol from cassava and other cereals for the industrial, pharmaceutical and beverage market in the domestic sector.

Nigeria's Potentials in Biofuel Production

National statistics suggest that more than 400,000 hectares of land could support high yield sugarcane operations in the country. At the same time, Nigeria is a leading cassava producer. The crops would be used in the first instance to create a 10 percent biofuel- 90 percent fossil fuel blend (see www.**nigeria**first.org/article_4301.shtm-30k
www.onesky.ca/RETs_ExecSummary_ObuduCaseStudy.pdf)

According to an official of Nigerian National Petroleum Corporation's (NNPC) Renewables Division, "two potential crops have been identified for the fuel ethanol initiative in Nigeria: sugarcane and cassava". Furthermore, "Nigeria is currently reputed to be the leading producer of cassava in the world of about 30 million tons annually. The potential must be seen against the background that the average yield in Nigeria is put at about 15 tons per hectare as compared to 25 to 30 tons per hectare obtainable in other countries (NNPC, 2005). Moreover, cassava is most perceived as a food crop in Nigeria and not as an industrial crop, part of which the biofuel program is expected to radically change." Though the cultivation of industrial sugarcane suffered a serious setback due to the poor performance of the government-owned sugar companies (now privatized), there is no doubt about the huge potential for growing sugarcane on a large scale in Nigeria, particularly along the entire length and breadth of the Niger and Benue rivers. The states of Jigawa in northern Nigeria, and Benue and Taraba in the middle belt region of Nigeria are targets for further agricultural development, and further feasibility studies are planned for individual locations within each State.

According to the Group Managing Director of the NNPC, Nigeria would be $150 million (about N21 billion) annually richer when [it] adopts the development and application of biofuel as an alternative energy source to crude oil. The official said as part of the implementation of the project,

special research initiatives would be sponsored by NNPC to boost cassava and palm-oil output within the Country and that the venture would lead to the setting up of several ethanol production plants at an average cost of $60m each.
He said further that the ethanol programme was expected to improve automotive exhaust emissions in the Country, reduce domestic use of petrol, free up more crude for export and position Nigeria for development of green field. NNPC, he said, had gotten a grant of 70,000 Euros from Renewable Energy, Energy Efficiency Partnership (REEEP) from Germany to support detailed feasibility study at the target locations (NNPC, 2005). An analysis showed that the current national average Cassava yield of 15 tons per hectare will be marginal while the current sugarcane yield of 60 tons per hectare are sufficient. To this end, improving Cassava yields becomes an imperative.

Bio-fuel or bio-diesel energy potential in Obudu Plateau, Cross River State, for example, could be guaranteed due to the existence of suitable bio-physical conditions for the cultivation of energy crops. The Jatropha (energy crop) species which is currently being exploited for energy production and other uses in Mali, Tanzania, Zambia, Ghana, is known to be growing in most of the Northern Cross River State. Moreover, the Jatropha could be cultivated at the drier parts of the Ranch where a related energy plant (castor oil seed recently promoted by the Cross River State Government) is currently being grown. The suitability of the Cross River State's biophysical conditions for the cultivation of the Jatropha includes the fact that Cross River State in general and the drier part of the ranch as well as the larger Ogoja region including Obudu, Obanliku and Ikom Local Government Areas where Protea Hotel currently gets diesel for running the generators not only possess the requirements for the cultivation of the Jatropha, the plant has been growing in the region but has not and is not being used for energy (bio-fuel) production (See www.onesky.ca/RETs_ExecSummary_ObuduCaseStudy.pdf)

The Potential Demand

The potential economic and social benefits of modern biomass energy arise from the fact that agriculture could face enormous demand for feedstock. This feedstock will need to be produced, harvested, transported, converted into biofuels, and distributed for final utilization. The size of the potential demand can be easily illustrated by looking at transportation fuels, where biofuels are still the only renewable alternative compatible with the current combustion-engine infrastructure.

Each day the world consumes about 21million barrels of gasoline and another 21 million barrels of diesel. These amounts translate into a potential demand of about 30 million barrels of ethanol and 23 million barrels of biodiesel a day. For illustration purposes only, if potential ethanol demand is translated into hectares of sugarcane or maize, the two major feedstocks for ethanol, then it would require the planting of 300 million hectares of sugarcane or 590 million hectares of maize—about 15 and 5 times, respectively, of the current world plantings of those crops. In the case of biodiesel, the potential demand would be equivalent to 225 million hectares of palm, or 20 times the current world plantings (European Union, 2006). The opportunities and challenges involved in meeting this demand in a sustainable and cost competitive manner should be a central concern in the development discussion.

The most advanced countries in biofuels owe their progress to economic incentives and domestic policies that have fostered the development of a bioenergy industry. These policies do not have to be protectionist in nature, but rather can spur market growth by setting national production targets or gasoline blending volumes. Many countries are now discovering the potential role that bioenergy could play in their economies and in the economies of countries that could markets for bioenergy services, such as Japan, as well as opportunities that tradable environmental goods may have for their economies.

Long-term Outlook of Biofuel Production in Nigeria

Like Brazil, Nigeria is taking a more top-down, supply-led approach than has perhaps been evident in other countries, many of whose policies are more market-driven. However, the government is not just looking to Brazil for information; it also plans to start up the industry using a Brazilian import partnership. Brazil is to initially supply Nigeria with fuel ethanol in order to develop the market and fuel supply infrastructure, and test out the ground. Both countries signed a memorandum of understanding in 2005. The import reception facilities at Atlas Cove and Mosimi areas are already being modified in preparation for the distribution of the biofuel (Osterkorn, 2006).

The recent surge in oil prices has made biofuels much more cost competitive with gasoline and spurred new investment. Ethanol and biodiesel production will continue to expand as long as world petroleum prices remain high. World oil prices have increased sharply since 1999, when the annual average nominal price of West Texas Intermediate (WTI) crude oil jumped from $19.25 per barrel in 1999 to $30.29 in 2000. Between 2000 and 2003, the average WTI price ranged from about $26 per barrel to $31 per barrel. In 2004, the WTI price increased to over $41 per barrel and the 2005 average WTI price increased to over $56 per barrel. DOE's Energy Information Administration's (EIA) short-term projections indicate that the average WTI price for a barrel will climb to $69 in 2006 and remain at that level in 2007 (European Union, 2006).

Higher crude oil prices have translated into higher wholesale and retail prices for gasoline and diesel fuel. EIA estimates that the average wholesale price for gasoline increased from $1.28 per gallon in 2004 to $2.04 per gallon in 2006. With average production costs (excluding capital costs) for ethanol at about $1.10 per gallon, ethanol was not competitive with gasoline at 2004 prices without the income tax credit. However, with the recent increase in gasoline prices, corn-based ethanol is competitive with gasoline even without the income tax credit.

Under EIA's long-term forecast, the real price of imported oil is expected to level-off after 2007 and perhaps show a slight decline by 2010. Nevertheless, world oil supplies are expected to remain tight as the demand for oil remains strong, keeping pressure on oil prices. If future oil prices reflect EIA projections, biodiesel and ethanol production will continue to grow with the rate of growth depending on the level of oil prices, feedstock costs, and changes in technology.

Practical Steps to Develop Nigeria's Potentials in Biofuel and Ethanol

In line with the European Union (2006), suggest five key policy axes, pulling together the measures government will take to promote the production and use of biofuel in Nigeria as suggested as follows:

1) Stimulating demand for biofuel

There is need to encourage policies that will favour biofuel (including second generation products),

2) Capturing environmental benefits

The need to examine how biofuel can best contribute to emission targets; work to ensure sustainability of biofuel feedstock cultivation; and look again at limits on biofuel content in petrol and diesel.

3) Developing production and distribution of biofuel

The need to set up specific groups to consider biofuel opportunities in rural development programmes; and increase monitoring to ensure no discrimination against biofuel.

4) Enhancing trade opportunities

Assess the possibility of putting forward a proposal for separate customs codes for biofuel; it will pursue a balanced approach in trade talks with ethanol-producing countries;

5) Research and development

Government should specifically support the development of an industry-led 'Biofuel Technology Platform' which will make recommendations for research in this sector. Through research, production costs could be cut considerably beyond 2010.

Research and development issues in biofuel in Nigeria should, therefore, focus on the following:

1. Assess the potential for scientific developments to contribute to greater and more efficient production of biofuel, primarily liquids for use in the transport sector. Fuels considered will include biodiesel, bioethanol, biobutanol, biogas, synthetic diesel and gasoline.
2. Review international policy, science and industrial experience, for example the USA and China biofuel research roadmaps and the European Technology Platforms.
3. Provide insight into relative priorities for research and development for biomass and each class of biofuel
   - Consider the barriers to further development, scientific or otherwise.
   - Identify research and development that should be funded publicly and that which would be better funded by industry
4. Highlight the gaps between the current situation and the potential that biofuel could realistically achieve, in terms of cost, yield and environmental performance - particularly greenhouse gas emissions savings.
5. Provide context for biofuel and consider how these issues will be affected by developments in the science and engineering, including:
   - Potential global production of biofuel and potential interaction with other land uses - for example food production, biodiversity conservation.
   - Identify potential environmental and socio-economic impacts of biofuel development, e.g. the consequences of increases in

feedstock production - including the environmental impacts and implications for public policy; local production and use versus transportation and wider distribution; developmental benefits.

- Consider range of potential uses for biofuel, for example in aviation and identify potential for innovation that this may provide.

Conclusion

Nigeria has great potentials in the renewable energy production mainly biofuel and ethanol. To fully develop and harness these potentials, new policy developments will of necessity involve all the ministries and governmental offices necessary so that they take into account all the issues related to the various links in the value chain. At this stage, the policy emphasis is to stimulate the emergence of integrated operations showing the most potential for good economic performance. At the same time, the policy will aim to set out the best conditions for the development of an "outgrower" scheme, which would involve the direct participation of local communities in the production of feedstock for the industry. It will also address access to the best international industry skills and financing available to underpin the sustained growth of the industry. The new industry will radically change the agricultural sector in Nigeria, which is currently dedicated only to food production, and will create thousands of new jobs as Africa gears up for what is probably one of its first biofuel and certainly one of its many desperately needed agrarian revolutions.

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