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Potential, Barriers and Prospects of Biogas Production in North-Central Nigeria

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ABSTRACT

Despite research work and implementation of biogas having started as early as in the 1980s, Nigeria is lagged behind in the adoption and use of biogas in the sub-Saharan Africa. The study established that there is a theoretical biogas potential of 76PJ per annum from animal manure and crop residues. This is sufficient to provide energy for cooking and lighting in more than 16 million households. Lack of funding, lack of policy, regulatory framework and strategies on biogas, unfavorable investor monetary policy, inadequate expertise, lack of awareness of the benefits of biogas technology among leaders, financial institutions and locals, resistance to change due cultural and traditions of the locals, high installation and maintenance costs of biogas digesters, inadequate research and development, improper management and lack of monitoring of installed digesters, complexity of the carbon market, lack of incentives and social equity are among the challenges that have derailed the adoption and sustainable implementation of domestic biogas production in Nigeria. Unless these are addressed, it is unlikely that the biogas sector in Nigeria will flourish.

Keywords: *Biogas,Digester,Implementation,Installation,Research.*

1 INTRODUCTION

Biogas technology is an alternative source of energy that utilizes various organic wastes in order to produce biogas. Some countries that lack natural abundance or inadequate distribution of energy supply have over the years adapted biogas generating equipment to meet rural energy needs.in the 1970s when renewable energy became recognized as an entity. A conference was held at imperial college, University of London where researchers agreed on the great potential for biogas technology in many countries of the world, focusing more on the developing countries. Biogas has provided an economically viable and sustainable means of meeting the thermal energy needs of china(7.5million), India (3million) and Nepal where over 37000 biogas digesters were installed from 1992 to 1998 (Deolle,1998). The rapid development of biogas technology in most European countries could be linked to various strategies employed by the respective countries, and most especially by the Renewable Energy Directive (RES) proposed by the European Union, which sets a

binding target for all Members States to reach a 20% share of renewable energies in the total energy consumption by 2020. Biogas is a gaseous fuel, which is produced by the fermentation of organic material. The main component of biogas is Methane gas and other gases like hydrogen sulphides, carbon dioxide, siloxanes and moisture also form a part of biogas. Biogas is generally produced in a closed container where anaerobic digestion takes place efficiently and the closed container is called biogas digester. It is called so since the digestion of organic matter takes place in the presence of bacteria. The bacteria present in the digester need to fed everyday with food waste and water.

2.0 Biogas Production and Composition

There are four stages in which the decomposition of bio-waste takes place: Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis. The first step of the digestion process is bacterial hydrolysis (of the input materials. This is done in order to degrade the organic polymers which are insoluble in nature, for example, carbohydrates. The next step is to convert amino acids and sugars into ammonia, carbon dioxide, hydrogen and organic acids

Table 1. Specific Composition of Biogas

Compound	Formula	percentage
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0.5

Figure 1: A typical stove burning with Biogas.

The process of anaerobic digestion for the production of biogas is usually made to take place in a cylindrical tank that is air tight. These air tight cylindrical tanks are called anaerobic digesters. Concrete bricks or cement or steel ae used to build up the digester, which is usually built underground. The mixing tank has an inlet attached to it, this is for feeding in the cow dung. A gas outlet is also present. The slurry or the used cow dung is made to come out of an outlet present in the digester. This slurry which comes out of the digester can be used as manure. When cow dung is used as a substrate, the process takes around 2-3 week.

3.0 Different Solid Wates from which Biogas can be Generated

A few solid wastes from which biogas can be generated are:

3.1. Food wastes or green wastes:

Food that is discarded or left uneaten are called food wastes, basically the wastes that are produced by food items are called food wastes. Food waste, decomposable organic matter and kitchen waste which consist of a little amount of carbon dioxide and of methane, are used to produce biogas, which is then used as an alternative for cooking gas or LPG. Also, the waste materials can be disposed of efficiently without leaving behind any odour or flies. The slurry or the digested slurry obtained can then be used as organic manure in gardens.

4.0 PROSPECTS OF BIOGAS TECHNOLOGY IN NIGERIA.

With a stable climate and easy availability of plant materials and wastes (cow dung, poultry droppings, pig excreta among others) coupled with the current positive shift in agricultural policies of government, Nigeria is in a good position for adopting and popularizing biogas. At present, much of dung produced by about millions of herds of cattle in is either wasting or burnt away as wasteful cooking fuel. Biogas is not widely known in Nigeria much of the materials available in Nigeria are reports of scientific researchers into the technical aspects and basic factors fo biogas production, especially on raw materials (Garba and Ojukwu,1998, Zuru et al,1998). However, The Federal government in 2001 established the National Biotechnological Development Agency (NABDA) that is mandated among others to develop conservation strategies to promote sustainable utilization of Nigeria's enormous biological resources and to facilitate the speedy evaluation and utilization of the processes and products of biotechnology while ensuring environment stewardship (Omaliko, 2006).

In Nigeria, some biogas projects have been executed, including construction of biogas plants at Zaria prison in Kaduna, Ojokoro in Lagos, Mayflower School Ikene in Ogun State, and a biogas plant at Usman Danfodiyo University in Sokoto with capacity of the digesters ranges between 10 and 20m3 (Abubakar However, the biogas projects are yet to be commercialized, since most of them are either non-operational or still at the research stage.

4.1 Biogas Production from Crop Waste

Agricultural crop wastes are potential sources of biogas energy, especially in Nigerian rural areas where nearly everyone practices farming. Nigeria produces a wide range of agricultural crops in large quantities for consumption and exportation, and consequently huge amount of residues are generated from the crops after harvest. Agricultural crop wastes comprise of rotten crops due to inadequate storage facilities, Infected crops due to diseases and also residues produced from crop processing after harvest. As regards animal fodder, the most commonly fed crop residues include cassava and yam peels, cowpea husk, and groundnut husks, brans, oilcakes, maize, millet, and sorghum stovers (DE-Leew 1997; Onwuka et al. 1997; Singh et al. 2011). Leguminous crop residues are often preferred to cereal residues as animal fodder due to their higher nutritive value, digestibility, crude protein content, and minerals (Owen 1994). This greatly affect the quantity of crop residues available for biogas production. Taking the crop residues used for other purposes into consideration,

the quantity of available crop residues for biogas production was estimated at approximately 52 million tonnes, from which 21 billion cubic metres of methane gas could be generated at 35^0c.

5.0 HARNESSING BIOGAS OPPORTUNITIES IN NORTH CENTRAL STATES OF NIGERIA

5.1 Plateau State.

The government of Plateau, the twelfth largest state in Nigeria, located circa in the center of the country, has developed and signed off a new policy to advance the development and deployment of renewable sources of energy to its residents. The three policies – State Policy and Strategy on Renewable Energy, Plateau State Rural Electrification Plan, and the Public Private Partnership (PPP) Guidelines for Solar Mini-Grids, was recently launched by the state at the third edition of the annual National Council on Power (NACOP) hosted in its capital, Jos, with the state asking the Rural Electrification Agency (REA) to now look its way for more projects. Going by this adoption of renewable energy in Plateau state is still at planning level.

5.2 Benue State

The Nigerian National Petroleum Corporation (NNPC) is set to conclude on the choice of a core investor for the proposed Bio-fuel plant in Agasha Guma area of Benue State. The NNPC said upon completion, the plant was projected to generate about one million direct and indirect jobs for the populace noting that the project would help link the energy sector with the agric. sector through the commercial production of biofuels from selected energy crops. Other components of the project include a sugar cane feedstock plantation of about 20,000 hectares; a cane mill and raw/refined sugar plant capable of producing 126,000 tonnes annually as well as a fuel-ethanol processing plant with production capacity of 84 million litres annually. The bio-fuels projects will also help to establish the Bio-gas cogeneration power plant which will generate 64 MW; a carbon dioxide recovery and bottling plant that will produce 2, 000 tonnes annually as well as an animal feed plant that will produce 63, 000 tons annually. This also shows that Benue state is yet to start using biogas as a fuel at commercial scale.

5.3 Kwara State

The home biogas units are also said to be simple to operate, and require minimal annual maintenance, and although the biogas can be burned on a regular stove, at least one burner does need to be converted to use the fuel. The Department of Agricultural and Biosystems Engineering, University of Ilorin, Kwara State has conducted series of local researches on biogas, organic fertiliser and biofuel development. With the efforts so far, Kwara state is confident that the technology with the lowest capital and operating costs that would allow more Nigerians generate fuel from organic waste.

5.4 Nassarawa State

FCT Administration Sets up Biogas plant at Abattoirs in Karu Nasarawa state. Poor sanitary condition of abattoirs in the Federal Capital Territory has been a challenge to the government, residents and other stakeholders, who depend on the slaughter houses for their daily meat needs. The poor environmental condition of most abattoirs is said to have contributed to the spread of diseases, which help in endangering human health. In a bid to address the challenges, the government had made several efforts but the conditions have persisted, creating anxieties in the minds of residents. Secretary of Agriculture and Rural Development Secretariat, Federal Capital Territory, Stanley Nzekwe, said that when he assumed office, the condition of abattoirs in FCT was so poor, that he had to start work towards evacuating animal dung that was allowed to pile up everywhere in these abattoirs. Recently, the sanitary condition of the abattoirs attracted the attention of an International Environmental Organization, African Environment Action Network(EANet-Africa). The organization has taken some steps to provide a biogas plant said to have the capacity of addressing the challenges of evacuation of animal waste in these slaughter houses.

5.5 Niger State

Niger State (Nigeria) was selected as a case study of renewable, affordable and user friendly clean energy provision in remote areas of developing countries. Niger state has 80% of its 4.5 million population living in rural agrarian areas with low literacy rates, there is a lack of wind thus eliminating wind as widely available potential power source. Based on the assessment of the local large insolation, the type of agricultural, biomass and husbandry resources, this study selected the design of anaerobic digestion units processing mostly animal and human waste, and whose heating and power requirement would be entirely provided by solar photovoltaic/thermal to maintain optimum efficiency of the biogas production. The designs were carried out at the scale of up to 15 household demand (community scale), Volume and therefore the production of biogas maybe increased or decreased in the design considered, and local, low cost resilient material were proposed. The proposed system was costed for a community of 24 people, demonstrating the potential for clean and renewable gas production economically. This also shows that in Niger state adoption of biogas as a commercial source of energy is still at proposal stage.

5.6 Kogi State

The Nigerian National Petroleum Corporation (NNPC) and the Kogi State Government have signed a Memorandum of Understanding (MoU) for the development of a sugarcane-based fuel ethanol processing plant that would produce 84 million litres of biofuel per annum. The MoU was signed in Abuja on February 27 between Dr Maikanti Baru, Group Managing Director of the Nigerian National Petroleum Corporation (NNPC) said that the MoU was "another milestone in the history of the state." According to Dr Baru, the signing of the MoU would lead to the formation of a Special Purpose Vehicle (SPV) to steer the future activities of the proposed Kogi Biofuels Project in Kaba/Bunu. The sugarcane feedstock would require 19 000 hectares and Dr Baru stated that discussions had been held with the various parties and stakeholders on the Kogi Biofuels Project on the modality for the implementation, adding that agreements had been reached on the first stage of the project.In addition, the Alape Staple Crop Processing Zone (SCPZ) in Kogi State, provides suitable agronomics for the cultivation of sugarcane, cassava and oil palm.

6.0 CHALLENGES OF SUSTAINABLE BIOGAS USE IN NIGERIA

6.1 Policy and strategy

Biogas technology transfer requires good fiscal policies which provide incentives. There are no such fiscal policies to encourage investment in biogas technology in most sub-Saharan African Countries Energy policies and strategies put in place by governments are not focused and thereby fail to achieve their intended goals of attracting both domestic and foreign investments in biogas production.

6.2 Inadequate expertise and training

Lack of skilled and experienced masons to undertake the construction and maintenance of biogas plants is a constrain hindering the fully dissemination and adoption of biogas production in Nigeria. Universities in Nigeria have not designed and implemented appropriate programs to teach and train students in biogas technology.

6.3 Research and development

Presently, the research institutes are not adequately equipped as far as renewable energy research and development is concerned. Research funds are often not adequate or are misapplied. There has not been enough research in higher learning institutions on biogas technology due to non -support from responsible government ministries

6.4 Feedstock availability and other technical issues

Though technically available, feedstock maybe practically inadequate due to a number of reasons, such as grazing patterns of animals, location of fields, farming practices. Where one kind of feedstock is inadequate, co-digestion may just be the answer. Information is required on how to pretreat the manure before adding it to the digester and how much water should be used.

6.5 Lack of political will

Suberu et al. (2013) argue that political will is among the most important factors that have a significant impact on determining the amount of renewable energy in the national energy mix. In Nigeria political will in renewable energy has lagged behind as compared to other developing countries elsewhere across the globe

6.6 Resistance to change

Inertia to change from use of primitive energy forms to modern energy such as biogas has been attributed to customs and traditions in some communities. The perceived unreliability of biogas also has contributed to resistance to change in some instances. A study conducted in Nasarawa state and results showed that there is a tendency among urban dwellers, especially those in the peri-urban areas, to continue using charcoal or firewood because they feel it is cheaper even when their homes are connected to the grid

6.7 Financing

Financial institutions often perceive the bioenergy sector as high risk, making it very challenging for investors to obtain funds. Inadequate funds to finance power generation, transmission and distribution coupled with low rates of returns due to high operating costs and low consumption are some of the challenges faced by some North central states in Nigeria.

7.0 CONCLUSION

The future is green energy, sustainability and renewable energy. To make life possible without a hitch, alternative sources of energy should be used. Utilization of biogas reduces global warming and also prevents harmful diseases. The availability of feedstock for biogas production in Zambia is adequate. Cow dung being and maize cobs are the major feedstock sources among the animal waste and crop residues respectively. There are many technical and socioeconomic constraints that have hindered full adoption and sustainability of biogas production in Zambia. Lack of mobilization of external and local funds, the complexity of the carbon market, lack of policy, strategy and regulations in biogas production, high capital and maintenance costs, lack of trade and investment incentives, resistance to change among the beneficiaries, lack of co-operation between implementers of biogas projects and researchers, inadequate research and

development due to insufficient funding, low levels of full time equivalent researchers who are qualified at PhD level, inadequate expertise and training in biogas production and unfair equity are some of the major constraints hindering adoption and implementation of biogas projects in Nigeria. Developing and implementing renewable energy systems will increase security of national energy supply and reduce dependency on energy from fossils, it will also protect the environment in terms of climate change, as a result, of their uncontrolled emission into the atmosphere.

7.0 REFERENCE

Abila, N. (2012). Biofuels development and adoption in Nigeria: Synthesis of drivers, incentives and enablers. *Energy Policy* 43: 387-395.

Abubakar, M. (1990). Biogas generation from animal wastes. *Nigeria Journal of Renewable Energy* 1(1), 69-73.

Adewunmi, I. K., Ogedengbe, M. O., Adepetu, J. A., and Fabiyi, Y. L. (2005). Planning Organic fertilizer industries for municipal solid wastes management. *Journal of Applied Sciences Research* 1(3): 285-291.

Agbo, K.E., and Eze, J.I. (2011). *Anaerobic digestion of municipal solid waste for generation of energy: prospects and challenges in Nigeria*. Nigeria Journal of Solar Energy, 22: 130-137

Akpan, U.S.' and Ishak, S.R. (2012). Electricity Access in Nigeria: is off-grid electrification using solar photovoltaic panels economically viable? A sustainability, Policy, and Innovative Development Research (SPIDER) Solutions Nigeria Project. (Interim Report).

Amori, A. A., Fatile, B. O., Ihuoma, S. O., and Omoregbee, H. O. (2013). Waste generation and management practices in residential areas of Nigerian tertiary institutions. *Journal of Educational and Social Research* 3(4):664 – 670.

Arthur, M., Zahran, S., and Bucini, G. (2010). On the adoption of electricity as a domestic source by Mozambican households. *Energy Policy* 38: 7235-7249.

Atuanya, E. I., and Aigbirior, M. (2002). Mesophilic biomethanation and treatment of poultry wastewater using a pilot scale UASB reactor. *Environmental Monitoring and Assessment*. 77:139-147.

Babayemi, J. O., and Dauda, K. T. (2009). Evaluation of solid waste generation categories and disposal options in developing countries: A case study of Nigeria. *Journal of Applied Science and Environmental Management.* 13, 83-88.

Blight, G. E., and Mbande, C. M. (1996). Some problems of waste management in developing countries. *Journal of Solid Waste Technology Management*. 23(1):19-27.

Bond, T., and Templeton, M. R. (2011). History and future of domestic biogas plants in the developing world. *Energy for Sustainable Development* 15: 347-354

Chaggu, E. J., Mashauri, A., VanBuren, J., Sanders, W., and Lettinga, J. (2002). Profile: Excreta disposal in Dar es Salaam. *Journal of Environmental Management*. 30(5): 609-620.

Chen, Y., Yang, G., Sweeney, S., and Feng, Y. (2010). Household biogas use in rural China: a study of opportunities and constraints. *Renewable and Sustainable Energy Reviews* 14(1):545-549.

Dangogo, S. M., and Fernando, C. E. C. (1986). A simple biogas plant with additional gas storage system. *Nigerian Journal of Solar Energy*. 5:138-141.

Davis, M. (1998). Rural household energy consumption: The effects of access to electricity-evidence from South Africa. *Energy Policy* 26: 207-217.

Federal Ministry of Environment (2005): *policy guideline on solid waste management*, Federal Republic of Nigeria.

Gerardo, B., Et al (2001): Solid Waste Characterisation Study in Guadalajara Metropolitan Zone, Mexico.Waste Management and Research. 14 (6): 338 – 346.

Igbinomwanhia,D.I (2010):Characterization Residential Solid Waste In Benin Metropolis, Nigeria. *International Journal of Engineering*, 4(4): 479-486.

Igbinomwanhia, D.I. and E.N Ohwovoriole (2011) A Study of the Solid Waste Chain in Benin Metropolis, Nigeria. *Journal of Applied*

Sciences and Environmental Management, 15 (4): 589 – 593.

Igoni, A.H., Abowei, M.F, Ayotamuno, M.J., and Eze, C.L. (2008). Effect of total solids concentration of municipal solid waste on the biogas produced in an anaerobic continuous digester. *Agricultural Engineering International: The CIGR E journal.* 8(6):11 – 22.

Ikelegbe, O.O and Ogeah, F.N. (2003). Perception and response to the challenges of environmental sanitation problems in Benin City and its environs. *Benin Journal of Social Science*, 12(2), 189 -200.

Ogweleka, T.C. (2003). Analysis urban solid waste in Nsuka , Nigeria. *The journal of Solid Waste technology and Management, Department of Civil Engineering Widener University, Chester, U.S.A,* 29(4):668 – 690.

Sadjere, E.G and Ariavie, G.O (2012). Determination of electrical energy equivalent of a typical household in the Niger Delta region of Nigeria. *International Journal of Academic Research*, 4(3): 180 – 196.