BIOFUEL CONTINUE TO BE ENERGY SUSTENANCE OPTION FOR DEVELOPING COUNTRIES A CASE STUDY OF MAIDUGURI METROPOLITAN, BORNO STATE.

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Abstract: *This paper investigate the potentials of some second generation bio fuels such as manure, tuber peels and other by-products of agriculture in providing biogas, bio ethanol and bio diesel. It identifies workable options which can help in meeting energy demand particularly in the developing world like Nigeria. Also, country- level partnerships in respect of energy exploitation, delivery and application: particularly in the areas of development of enabling policies, technology deployment, human resources provision and concessionary financial assistance are recommended. As part of the investigation work, organic wastes were used for the generation of biogas, as biomasses are in abundance in Maiduguri and its environment. The generation of energy, from organic wastes (animal wastes), millet stalks, which is the biomass used in carrying out the experiment, and also cell lysate and then a digester was used for the fermentation which is a drum type digester. The result shows that, from the digestion of organic wastes (biomass) and the cell lysate, methane gas was obtained as the biogas. The production shows that about 60-70% of methane and 40% of carbondioxide were obtained. Other gases obtained were hydrogen sulphide 0.5%, sulphurdioxide of about 0.4-0.6%.The maximum temperature maintained was about 50-60^{0}F(=28^{0}C) . This research showed that organic wastes could serve as an alternative to energy source.*

Keyword: Renewable Energy, Biomass, Bio Fuels, Policy Initiatives.
Receive for Publication on 30 December 2015 and Accepted in Final Form 6 January 2016

INTRODUCTION

Scientific interest and research into renewable energy technologies are still relevant, especially in view of the often very high costs of fossil fuels worldwide. Another reason for their relevance is the fact that the rampant use of firewood for domestic and industrial heating in low income countries invariably necessitates the destruction of forests and this is harmful to the environment. Also, it had been pointed out that the use of firewood, kerosene and charcoal in households had adverse effects on human health (Adelekan and Adelekan, 2004). Furthermore, using waste biomass to

produce energy can reduce the use of fossil fuels, reduce greenhouse gas emissions and reduce pollution and waste management problems (Marshall, 2007: Inderwildi and King, 2009). Overall, these reasons are compatible with the aims and objectives of the Kyoto protocol which are tailored towards the reduction of greenhouse gases. According to IEA (2010a) bio energy currently provides 10% of global energy supply, 1.3% of electricity production, and 1.5% of transport fuels .Among the aims of this paper is to investigate energy production from organic wastes which can serve as part of bio fuel and also provide energy sustenance in both rural and urban areas as part of development goal. A variety of conversion technologies are available and a range of feed stocks can be used namely wastes, agricultural and forestry residues, and crops grown specifically for energy purposes. Driven by increasing concern over energy security and green house gas mitigation, the global demand for liquid bio fuels more than tripled between 2000 and 2007. Production costs are uncertain and vary with the feedstock available, but are currently estimated to be USD 0.80 – 1.00 per litre of gasoline equivalent. Most bio fuels are currently produced from first generation feed stocks (food crops). An environmental concern over electric power generation from conventional sources has led to widespread public support for renewable energy sources. Governments throughout the world have responded by providing various forms of financial incentives to promote power generation from renewable energy sources. To this regard, renewable energy has attracted a very realistic global interest being the only viable option available to man for providing solution to energy. Development of renewable energy from biomass is one of the major promising alternative energy resources because of its presence in almost every part of the world. The availability of sun, biomass, and wind in Nigeria makes it the most viable option to get the country out of this quag mine of epileptic power supply. This paper will dwelled much on biomass option for Nigeria. Anaerobic digestion provides a means for treating organic wastes. Biogas production by digester has been regarded as an attractive method to deal with the concern of growing wastes disposal showing energy crisis simultaneously (Barker, 1989). Also higher temperature favours the growth of thermophilic bacteria and the fermentation rate is considerably faster (Chittenden et al, 1980). Lingo celluloses which are the major components of plants residue can be degraded by actinomyceted . This is one of the reasons why compositing is sometimes carried out. It helps in breaking down of the complex structures of the plants to simple ones, which can be easily degraded by animals (Crawfort et

al, 1997). In 1997, Professor Adeniji of the University of Maiduguri designed and constructed biomass digester utilizing Cow dung for the production of methane gas.

Aim

This paper intends to highlight a very practical information for decision makers in the developing countries for rural/urban energy sector. So that the potential of biomass production in terms of using it for energy production and also to look at the benefits when it is used for energy production and its environmental impact when it is used in power production. Though some of the technologies for these resources have been developed or domesticated but they are usually designed for meeting small isolated energy supply needs, like in Maiduguri and its surroundings. Most of the developing country have problem of highly inefficient Electricity Distribution Network. A suitable and efficient Renewable Energy Technology will be the solution to this part of the world. This is because the abundance of wind (2 – 4 m/s speed for upward of 17 hours) and solar power that ranges between (3.5 and 7.0KWh/m^2/day^{-1}) and available for between 8 and 10.5 hours and energy of 442 Mw from biomass is possible in an average population of 16 million people . This type of energy could be a visible solution that can be harnessed together of singularly to deliver a majority of people from poverty. This paper also, will try to discuss renewable source in particular biomass and developed it into a major energy source beyond domestic supplies.

There are a number of criteria which have to be considered, such as:

- Availability of energy resources within Maiduguri
- National and local economic conditions
- Financing options and markets
- Local and global environmental impacts
- Employment and other social impacts
- Technical capabilities and human resources
- Institutional capacity

It is widely recognized that, for energy strategies to be sustainable, an approach is required which will combine all of these complex and interlinked aspects

Objective

The objective of this paper is to develop a renewable energy information plan for developing countries, especially like Nigeria.

Availability of Energy Resources

Due to the growing demand for power, we are facing a significant increase in society's expenditure on electricity supply. Under the reference scenario , the undiminished growth in demand , the increase in fossil fuel prices and the costs of CO_2 emissions all result in electricity supply costs rising from today's $ 1, 130 billion per year to more than $4 ,300 billion per year in 2050. A scenario that not only complies with global CO_2 emission targets but also helps to stabilize energy costs and thus relieve the economic pressure on society should be developed. Increasing energy efficiency and energy supply to renewable energy resources leads long term costs for electricity supply that are one third lower than where we are at present. It becomes obvious that following stringent environmental targets in the energy sector also pays off in economic terms. The obvious choice(s) is the renewable energy .Like in Nigeria being the country is divided politically into 6 geo-political zones. The country has abundance of solar energy with more being available in the Northern part of the country. The Southern part however, is suitable for wind power –especially the coastal area that has well over 500 kilometers. The biomass is well distributed, as almost equally big cities exist in all the geo-political zones. In this paper emphasis is laid on biomass because of its availability in Nigeria .In Maiduguri and its environment with abundance of bio-mass from which biogas can be generated.

In recent times, there has been renewed interest in biomass energy development due to several factors, some of which are:

1. Growing concerns about climate change-biofuels can be carbon neutral if they are produced in a sustainable way.
2. Technological advances in biomass conversion, combined with significant changes in the global energy market.
3. Biofuels have the unique characteristics of being the only source of renewable energy that are available in gaseous, liquid, and solid states.
4. Increasing focus on security of energy supply and
5. Increasing interest in renewable energy generally.

Table 1: Types of Plant Biomass in Nigeria.

Woody Biomass	Non-Woody Biomass	Processed Waste	Processed Fuels
Trees	Energy crops such as sugar cane	Cereal husks and cobs	Charcoal(wood and residues)
Shrubs and Scrub	Cereal straw	Bagasse	Briquetted or densified biomass
Bushes such as coffee and tea	Cotton, cassava, tobacco stems and roots ()partly woody	Waste from pineapple and other fruits	Methanol and ethanol(wood alcohol)
Sweeping from forest floor	Grass	Palm oil cakes	Plant oils such as palm, rapeseed(canola) and sun flower
Bamboo	Bananas and Plantains	Sawmill waste	Producer gas
Palms	Soft stems, such as those of pulses and potatoes	Industrial wood bark and logging wastes	Biogas
	Swamps and water plants	Black liquor rom pulp mills	
		Municipal wastes	

Table 2: Nigeria's Size and Land Use Parameters

NIGERIA	QUANTITY (million bar)	PERCENTAGE %
A. SIZE		
Total Area	92.4	100
Land Area	79.4	85.9
Water bodies(rivers, lakes etc)	13	14.1
B. LAND USE		
Agricultural Land	71.9	77.8
Arable Cropland	28.2	30.5
Permanent Cropland	2.5	2.7
Pasture Land	28.3	30.6
Forest and Woodland	10.9	11.6
Fadama	2	2.2
Others	7.5	8.1

Source (REMP, 2005)

Urban and Wastes and other Wastes

There are wastes generated due to the daily activities of people and can be categorized into municipal solid waste, sewage waste, food waste and fat, oil and grease:

(i) Municipal solid wastes: These are wastes generated by households and commercial concerns as a result of population concentration and activities in urban areas. The generation of municipal solid wastes increases with increasing human activities such as industrialization and urbanization (Beukering et al , 1999;Peilling and Thomas-Hope, 1999).The municipal solid wastes (MSW) in Nigeria contain all sources of unsorted wastes such as commercial refuse, construction and demolition debris, garbage, electronic wastes, which are dumped indiscriminately on roadsides and any available open pits irrespective of the health implication on people(Onwughara et al, 2010).

(ii) Food industry waste: Solid and liquid food wastes are generated by the food industry, hotels and restaurant. These include foods that are not up to the specified quality control standards, peelings and remains from crops, fruits and vegetables. Restaurant and hotels contributions to the GDP of the country are on the increase. Nigeria with a population of 170 million, the wastes that are generated from the food industry will be considerable. Presently, most solid wastes end in the waste dumps while the waste water from food industries which contain sugars, starches and other dissolved and solid

organic matter usually constitute environmental pollution. These food wastes can be anaerobically digested to produce biogas or fermented to produce ethanol.

(iii) Industrial waste water/sewage sludge/bio solids: Large amounts of wastewater are discharged from industries and may be organic or inorganic requiring each industry to develop different methods of wastewater treatment depending on the characteristics and amount of wastewater. These methods were classified by (Bhattacharya et al,2005) as:

(a) Physical unit processes (screening, mixing, flocculation, sedimentation, floatation, and filtration).

(b) Chemical unit processes (precipitation, adsorption, and disinfestations).

(c) Biological unit processes (aerobic processes, anaerobic processes, anoxic denitrification).

Animal Wastes

Animal wastes (or manure) are mainly the droppings of livestock animals. The main constituents of this waste are organic material, moisture and ash. When decomposed under aerobic conditions, CO_2 and stabilized organic material are produced in anaerobic conditions. The quantity of manure produced generally depends on the amount of feed consumed, the quality of the feed and the live weight of the animal (Duku et al, 2011). Livestock generate huge amount of manure daily which can be converted into biogas by anaerobic digestion. Animal wastes particularly ruminant offer potential for both direct and combustible fuel and as input to produce biogas.

Bioenergy Potentials in Nigeria

Increasing attention is being focused globally on bio energy as alternative to depleting fossil fuel. The suitability of a particular biomass as a potential feedstock for bioenergy production depends on various characteristics such as moisture content, calorific value, fixed carbon, oxygen, hydrogen, nitrogen, volatiles, ash content and cellulose/lignin ratio (Duku et al, 2011). The drivers for increasing the use of biomass for energy (FAO, 2008):

(I) Possibility of reduced carbon emissions and meeting climate change commitments,

(II) Rural development through employment and increased livelihood and market opportunities,

(III) Reduction in fossil fuel consumptions.

(IV) Security of supply through local production and / or processing and

(V) Technological developments because bio energy could be used to bridge the gap between current fossil fuels technologies and future technologies.

The conversion of biomass to energy will be rewarding, given the large availability of biomass resources in Nigeria.

Biomass

The capture of solar energy as fixed carbon via photosynthesis is the key initial step in the biomass growing. This can be expressed mathematically as:

$$CO_2 + H_2O + \text{light} + \text{chlorophyll} \rightarrow (CH_2O) + O_2$$

In cities, daily human activities within domestic homes, commercial centers and industrial sites generate municipal solid waste (MSW). In Nigeria for instance we have about 4 cities that generate high level and volume of waste. The cities are Lagos, Ibadan, Port Harcourt, Kano and Abuja. Other smaller ones include Maiduguri, Benin City, Akure, Enugu etc. These are densely populated cities in Nigeria with total population in excess of 50% of the total population of Nigeria. The burden of municipal solid waste management can certainly not be ignored in such a heavily populated metropolis. An effective way of managing the waste is to apply a logic that will provide economic and environmental advantages. Municipal solid waste (MSW) is a composition of both organic and inorganic materials generated from series of human activities in industrial sites, domestic households, commercial centers and other institutional workshops. The presence of MSW in a society is a great problem if not well managed due to its ability to induce environmental degradation. In the past few years, the above Nigerian cities have witnessed rapid industrialization and demographic expansion. These twin developments have been responsible for the increase in volume of waste generation in these cities. This high quantity of waste generation symbolizes a greater opportunity for electricity generation in the form of alternative energy from bio waste resource. Organic fraction of municipal solid waste OFMSW is the most useful component of municipal solid waste. In advance nations, waste management is basically by land filling and combustion for energy in modern incineration or gasification systems. Among the industrialized nations, some countries developed policy framework for integrated waste management. An

integrated waste management system is a management system, which ensured that all benefits that can be derived from MSW are effectively utilized. In some countries, the organic fraction of the waste is treated by anaerobic digestion to produce biogas for fuel consumption. The traditional method of waste management in most developing countries is land filling and dumping in open areas. In majority of Africa countries, waste dumping in open areas is more prevalent. Waste management authorities of some organized cities in the region are more accustomed to land filling techniques for disposing their wastes while little is used for energy generation purpose. Due to high level of poverty in the region, human scavengers sometimes search for recyclables waste components in some open dump areas to make a living. Like other bio-energy resources, OFMSW is biodegradable. The composition of MSW generated in Nigeria include but not limited to paper , plastic ,textile , waste , vegetables , metal glass and hospital waste . A solid waste is one of the new sources of energy called renewable energy. Wastes from different sources have different description as activities generating the wastes are differing. The content of industrial waste shows some variation from that of household and commercial wastes illustrates from different sources. Major waste production in the metropolis comes from household activities, commercial, institutional and industrial operations.

How is Biomass used to Create Energy?

Biomass energy systems can be based on a wide range of feedstock. They use many different conversion technologies to produce solid, liquid and gaseous fuels. These can then he used to provide heat , electricity and fuels to power vehicles , using burners , boilers , generators , internal combustion engines , turbines or fuel cells . Power can be generated by:

- Co-firing a small portion of biomass on existing power plants
- Burning biomass in conventional steam boilers
- Biomass gasification, and
- Anaerobic digestion

Heat: The same power plants that produce power also yield useful steam and heat in combined heat and power (CHP). Biomass can be used in fireplaces and kilns to heat homes and at a bigger scale for "district heating".

Fuel: Unlike other renewable energy sources, biomass can be converted directly into liquid fuels for transport. The two most common bio fuels are ethanol and biodiesel.

Sources of Biomass

The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal wastes, waste from

forestry, agricultural, municipal and industrial activities. These are generally classified into three categories:

(i) **Natural Vegetations**

The natural vegetation used for biomasses are mainly used in the form of wood from trees. Wood is normally 50% cellulose, 25% hemicelluloses and 25% lignin. Dried wood has an energy content of $15 \times 10^7 metric\ tonne$, (Dort et al, 1978). The wastes from trees cut down for papermaking or timber contains cellulose for direct combustion after drying.

(ii) **Energy Plantation and Energy Crop**

Several authorities have estimated the land area needed for energy cultivation in order to provide a country's energy requirement. In 1993, calculations for the estimates shows that at 1% conversion photosynthesis efficiency, $1/10^{th}$ of the total energy requirements of the nation could be met by about 99% of the land area , (SCEGO et al ,1995) . The energy used in producing biogas should be less than the energy obtained in the out put, unless the energy form is not available from any other source. Example of energy crops are Eucalyptus pine, sugar cane, bites, sun flower, palms sweet sorghum e.t.c.

(iii) **Organic Wastes**

Organic wastes suitable for conversion into biogas include industrial wastes such as paper and pulp, urban garbage, domestic sewage and agricultural and forestry wastes (stalks, dung, branches, e.t.c.) .Other biomass sources are domestic refuse and agricultural wastes. High energy cost experienced presently will lead to a reassessment of the role of such wastes both as sources of energy and fertilizer.

The Principle of Biogas Formation

Organic materials and dead plants decays down, which are generally carried out by bacteria. Aerobic bacteria produces the decomposition in the presence of air while anaerobic bacteria affects it in the absence of air , gases escape and the residue is left , which is the manure , when decomposition takes place in the absence of air . Since, it is the gas needed, and then we involve anaerobic bacteria chemical reaction. During anaerobic process, three gases are evolved – methane, carbon dioxide hydrogen supplied. Therefore, when organic wastes are put in the container, no gas will be produced. The oxygen contained in the

slurry is consumed in the aerobic bacteria. Once the oxygen is used up, the anaerobic reaction commences. Thus, there is a time lag between feeding the wastes into the digester and the production of gas.

Purification of Biogas

Biogas is a mixture of Carbondioxide, Methane Gas, Carbondioxide, Hydrogen, Nitrogen, Hydrogen Sulphide and Hydrocarbon gas. The presence of Carbondioxide and Hydrogen Sulphide in biogas is undesirable and may be removed if desired.

Removal of Carbondioxide

Carbondioxide is colourless and odourless gas .It is heavier than air and does not support combustion nor does it burn itself. It's being removed from biogas by passing the biogas into limewater which turns milky due to the formation of calcium trioxocarbonate (iv)

$Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow Ca CO_{3(g)} + H_2O_{(L)}$ .....(1)

In excess, the water turns clear again due to formation of calcium hydrogen trioxo carbonate (iv) .

$CaCO_{3(s)} + H_2O_{(L)} CO_{2(g)} \rightarrow Ca(HCO_3)_{2(sq)}$ .....(2)

Alternatively, concentrated caustic potash solution could be used to absorb carbondioxide from biogas.

$2KOH_{(aq)} + CO_{2(g)} \rightarrow K_2CO_{3(aq)} + H_2O_{(L)}$.....(3)

Since it's soluble in caustic soda, it is absorbed as follows:

$2NaOH + CO_2 \rightarrow NaCO_3 + H_2O$ .....(4)

In excess caustic soda,

$NaCO_3 + CO_2 + H_2O \rightarrow 2NaHCO_3$ .....(5)

In the absence of these chemicals, the biogas can be passed through water in which case, carbondioxide reacts with water to form carbonic acid, a weak acid.

$CO_{2(aq)} + H_2O_{(L)} \rightarrow 2H_{(aq)} + CO_3$ .....(6)

Removal of Hydrogen Sulphide

Hydrogen sulphide is colourless, highly poisonous gas; it has a characteristic smell of rotten egg. It is removed from biogas by passing the gas through Lead acetate.

$CH_3COO_2Pb_{(aq)} + H_2S_{(g)} \rightarrow 2CH_3COOH_{(aq)} + PbS_{(g)}$ .....(7)

Hydrogen sulphide will precipitate many metallic sulphides when added to solution of metallic salts. When bubbled through solution of Copper (II) Sulphate (IV) Nitrate black precipitate are formed respectively, i.e. :

$CUSO_{4(aq)} + H_2S_{(g)} \rightarrow CUS_{(g)} + H_2SO_{4(aq)}$ .....(8)

$FeSO_4 + H_2S_{(g)} \rightarrow FeS + H_2SO_{4(aq)}$ .....(9)

$Pb(NO_3)_2 + H_2S_{(g)} \rightarrow PbS + 2HNO_{3(aq)}$ .....(10)

After absorbing carbondioxide and hydrogen sulphide, the balance is methane. Methane is colourless, non-poisonous gas, its much lighter than air, it burns in air with a luminous flame of heat in the process.

Factors Affecting Biogas Production

To facilitate optimum efficiency of biogas production, the condition in the biogas plants should be favourable to the bacteria involved. A number of factors such as, the nature of the organic wastes, concentration of the slurry, temperature,

PH value, degree of mixing, and even seedling with bacteria have been found to affect biogas production (Twiddel and Weir, 1990). In an experiment conducted, it was also found that the nature of the feedstock affects biogas production (Weir, 1992). The chemical composition of the feedstock determines the carbon contents, Nitrogen content and PH of the slurry and all these factors affects gas yield. Manure is found to have variable Nitrogen content and usually consists of faeces, urine and any bedding material like straw and corn/millet stalks. Since Nitrogen when excess in animals is excreted in the urine, then the Nitrogen content of the manure depends on the proportion of urine mixed with it. When also, different concentration of slurry are used, the volume of biogas produced increases with increase in concentration, until after a certain limit which it decreases. Stirring also affects the yield of biogas, but it's good to stir after feeding, but not continuously and not omitted completely because it could lead to scum formation which may cause a drop in the production of gas. The retention time, which is the time lag between feeding of the slurry into the digester and the time of gas production? Normally, this varies between 8-20 days, with gas production increasing with the number of days. Also, the capacity of the gas collector affects its production. The higher the volumes of the gas collector holder, the much gas it can hold at a time, thus enhancing the digester are of batch purpose.

Method of Biogas Production

Biogas can be produced using digester which ferments the biogas in the absence of air (anaerobically). Basically, there are two methods or types of digester namely: Drum type digester and Drumless type digester.

Drum type Anaerobic Digestion

The conventionally plant, originally developed at the Indian Agricultural Research Institute, New Delhi, (1935), of the drum type consists of masonny digester (i.e. fermentation tank), with an inlet pipe on one side for feeding the biomass mixed with water. The methane gas is produced by bacteria in either of the methods. The bacteria are anaerobic which operates only in anaerobic environment (i.e. environment that is free from air). Constant temperature in the drum type digester, PH and fresh organic matter promotes maximum methane production. Anaerobic digestion is a two parts process and each part is formed by a specific group of organisms. The first part is the breakdown of complex organic matter into simple organic compounds by bacteria. The served group of micro

organisms, the methane formers breakdown the acid in the methane (Vyas et al, 1989). In a properly functioning digester the two groups of bacteria must balance so that the methane formers can use just the acids produced by the acid formers. The gas produced in the drum type digester collected in a gas holder or drum-placed over the liquid surface.

Drum Less Type Anaerobic Digester

In this type, the pipe for gas flow can be connected directly to the burner or separately. There is no moving part as the whole digester (plant) is an underground well with gas outlet. It is provided with a sloping and smooth inlet on one side and a rectangular outlet on the other side for removal of used slurry. Biogas is also formed in the absence of oxygen and through the fermentation of biogas, which is taken out through a certain pipe fixed to the gas holder or drum.

Figure above shows various sizes of digesters

Figure above shows underground Dome Digester

Results Obtained for Three Weeks during the Research

Number of days	Gas produced	Quantity of gas (cm^3)	Effects
1 – 8	Carbondioxide (CO_2)	About 2 – 3	It does not support combustion
10 – 12	Carbondioxide (CO_2)	About 0.5 – 1	It does not support combustion
14 – 16	Methane (CH_4) and hydrogen sulphide (H_2S)	About 0.4 - 0.9	It has choking smell
18 - 21	Methane gas only	About 10 – 15	It burns with pale blue flame

DISCUSSION OF THE RESULT

With reference to the table above, which is after the anaerobic digestion, the gas being produced finally is the methane gas. For the first seventh day, a colourless and odourless gas was produced which shows that fermentation has started occurring. Also, on the tenth to twelfth day, the gas produced does not support combustion, which is carbondioxide. On the fourteenth day, methane and hydrogen sulphide gas was produced, which has choking smell. Finally, 10 – 15cm^3 of gas was produced after twenty – first day, which shows that methane gas is present. In anaerobic process of biogas production, temperature is considered an important

operational parameter. It has been discovered that lower temperature tends to favour the acid forming bacteria and the accumulation of volable acids which includes the methanogens and can even inhibit the process. In the course of the experiment, the millet stalks used were large and were also chopped into smaller pieces. Animal wastes in this case were already broken by the animal digestive track and chewing as the plants are being eaten (Lanman, 1974). Moisture content of the biomass can be contributing factor of gases evolving from the waste. A balance condition has to be maintained for the system to operate effectively. A successful operation of a digestion relies on the correct balance between various groups of bacteria involved in this process (Chiltenden et al, 1980).

Research Problems and Suggestion

The main problem of this experiment is the fact that it is dependent on the Pressure, Volume, and Temperature (P.V.T) scale of thermodynamics. At a lower temperature , the action of anaerobic bacteria of some kind that are good composer or decomposer are less active and this will definitely affect the gas production capacity of the digester . However, agitation of the digester creates a new pressure in the system, since the system air tight, there is always an increase of the temperature by setting organic wastes (biomass) and water content as digester in motion. This will increase the total kinetic energy of the system and a rise in temperature is achieved. Another problem encountered in this research work is the problem of linking (escape) of gases, which almost rendered this experimental work fruitless. The main cause of this is rusting which equally did not allow easy screw of the nuts and bolts. To my believe, the rusting is caused by the reaction between the surface of the metal and the water molecule. To solve this problem, grease was applied in most cases to aid loss the nuts and oily maintenance of the relevant arts of the digester. For the linking, araldite was used to glue the linking parts but in order to avoid subsequent linkage; it was mixed with small amount of sand so that force of adhesion is achieved in sealing the linking points. Another serious problem encountered was the blockage of the slurry inlet by the waste when feeding the digester. To avoid this , the millet stalk have to be chopped into smallest pieces before they are pushed down the inlet and not be mixed with water as much of water will be lost in the process of feeding the digester .

RECOMMENDATION

For any renewable energy generation, a renewable energy generator may be described either as *standalone or grid – connected* .In a standalone system a renewable energy generator (with or without other back-up generators or storage) supplies the greater part of the demand. In a grid-connected system, the renewable energy generator feeds power to a large interconnected grid, also fed by a variety of other generators. The best distinction here is that the power injected by the renewable energy generator is only a small fraction of that generated by the totality of generators on the grid. In this a standalone system is best recommended. Also, the heat generated by the usage of oven and heating of water or other items can be saved when our attention shifts to bio-mass. The bio-mass will provide the fuel needed to generate the energy. To make the energy revolution real and to avoid dangerous climate change, the following assumptions need to be implemented:

- The phasing out of all subsidies for fossil fuels and nuclear energy and the internalization of external costs
- The setting out of legally binding targets for renewable energy
- The provision of defined and stable returns for investors
- Guaranteed priority access to the grid for renewable generators
- Strict efficiency standards for all energy consuming appliances , buildings and vehicles

Nigerian Government Efforts with Regard to Bioenergy Development:

National Policies and Targets

The Federal Government of Nigeria sets out its vision, policies and objectives for promoting electricity derived from renewable energy sources in the Policy and Guidelines in Renewable Electricity. A study conducted by the Presidential Committee on a 25 year Power development plan developed a projected electricity demand profile for the nation of about 15,000 MW, 30, 000 MW and 190,000 MW in the short, medium and long terms on the basis of a 10% economic growth rate scenario (Sambo, 2006). A study by the Energy Commission of Nigeria indicated that renewable electricity is expected to contribute about 14, 23 and 36% of the total electricity demand in the short, medium and long terms respectively as dictated by the National Energy Policy (ECN, 2003).

Anticipated Benefits of Bio -Energy Industry in Nigeria and other Developing Countries

There are enormous benefits rural area stand to gain if bio -energy industry is properly developed in Nigeria as given by Agba et al, (2010). These benefits include:

(i) Employment and Wealth creation: Bio-energy will lead to modernization of rural agriculture including loans and agriculture incentives from government and the private sector. New jobs for highly skilled labour would be created in bio-energy industries and where dedicated energy crops would be cultivated. This in turn will increase the number of manufacturing facilities and jobs in the rural sector of the country. With an estimated 60% of the countries workforce employed in the agriculture sector, the attendant proportion would expand to about 70 to 80% when bio-energy industry is fully developed in the country. This would improve the earnings of rural dwellers thereby creating wealth.

(ii) Rural infrastructure development: Most rural areas in Nigeria lack basic amenities. The involvement in bio-mass resource cultivation, harvesting and processing could ginger up rural development by improving rural livelihood and creating new income opportunities. Bio-energy industry would attract and increase investments which would lead to the development of rural infrastructures such as portable water, roads, railways, electricity, hospitals and markets.

(iii) Rural market expansion: Bio-energy industry would attract other services providers that would create multiplier effects. Commercial activities would expand with increase in the demand for goods farmers. Those dwelling in the rural areas would also have access to varieties of goods and services.

(iv) Poverty reduction: Development of bio-energy industry would reduce rural poverty depicted by low income, unemployment and lack of basic amenities/infrastructures.

(v) Skill acquisition and increase in school enrollment: The bio-energy industry and other services providers would require skilled and semi-skilled labour which would lead to the establishment of

skill acquisition centers in rural areas. Scholarship would be provided to rural dwellers (host communities) as part of their corporate social responsibilities.

Limitations of Bio-Energy Industry in Nigeria/Other Developing Countries

Challenges of Bio-Energy Industry in Nigeria/Other Developing Countries

(i) Land ownership structure: Bio-energy industry would require large cultivation of energy crops. The current communally ownership of land, with a pocket of private ownerships would pose as hindrance to large scale farming which can affect the availability of new material for the bio-energy production.

(ii) Lack of infrastructure: Lack of basic amenities in rural communities would impede the effective development of bio-energy industry.

(iii) Fear of food shortage: There are likely fears that bio–fuels industry would threaten food security in rural areas.

(iv) Environmental problems: Some communities who are already suffering from pollution due to the activities of agri-based industries may be exercising fear that bio-energy industry would do the same which may impede its development.

(v)Lack of skilled labour: There would be need for specialized skilled workers in the new bio-energy industry as workers with requisite knowledge which may not be readily available for smooth running.

(vi) Inadequate funds: Cultivation of energy crops requires long term loans and incentives. Presently, the poverty situation in rural areas impedes farmers from getting loans and government incentives are also inadequate thus affecting productivity.

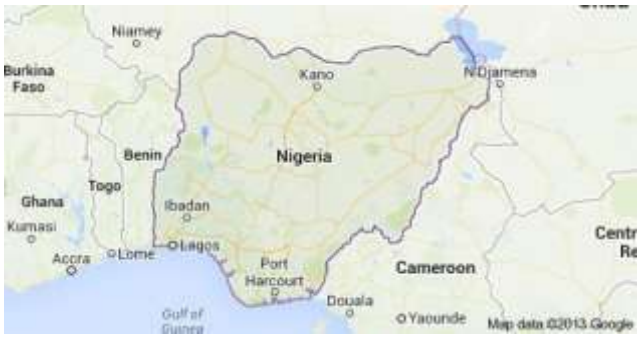

Figure above showing map of Nigeria boundaries

Research Gaps for Bio-Energy Industries in Nigeria

Some research gaps for the bio-energy industries in Nigeria as given by Sambo (2006) are enumerated below:

(i) Capacity limitation: Technical expertise to develop, deploy and manage renewable energy is inadequate and worst still, is not relied upon in the country as expertise is often sourced from outside the Nigeria. Also the infrastructure for the manufacture of renewable electricity system components is not available in the country.

(ii) Financial and fiscal incentives: Financial and fiscal incentives are not available to fast track the development of the supply and demand sides of the renewable energy electricity market. There is also a general lack of awareness of the benefits of renewable energy electricity in the country. No agency is presently charged with the responsibility to license smaller capacities which are often associated with the renewable energy electricity.

(iii) Intermittency of resource availability: All renewable resources for electricity generation are available intermittently and cyclic. There is also inadequate resource assessment and reliable resource database to assist investment decisions for renewable energy electricity industry. The challenge of energy storage and system management during periods of lack of resources adds to the complexity of the system.

Distribution of Economic Benefits

Most biomass facilities require harvesting operations, sometimes using highly mechanized operations often conducted by non-local operators. Thus the value of economic activity should be geared towards sharing the benefits of the economic activity with the objective of a high value/high return community based approach. Projects which can demonstrate the highest contribution to local economic development in disadvantaged areas should be encouraged. The creation of local economic value is substantially affected by the degree to which value-added enterprises are integrated with biomass utilization facilities. Proposals which develop or encourage co-location of value-added enterprises with biomass facilities will generate significant greater economic value while reducing the local demand on resources.

CONCLUSION

Almost every organic waste will produce methane gas, but with all things being equal, some are better. Generally , animal wastes produces higher yields of gas over a shorter length of time than vegetable wastes due to the fact that animal waste are partially digested by the animal digestive system. Vegetable wastes especially azadirachta indica although gave out a higher quantity of gas, it takes

longer time to be digested in an anaerobic conditions and may not therefore be practically producing higher amount of gas than animal wastes. Methane gas generated from organic waste is used for firing ceramic works, can be used as source of energy in cooking and can easily be constructed. Methane gas can be cheaply produced in this manner with the advent of energy crisis and ever rising process of fossil fuels. Instead of collecting and burning the wastes, which pollutes and cause greenhouse effects to the environment, they can be used in digesters where environmental hazard like air pollution and cost of revitalization of environmental damages are going to be reduced. Concerns for energy conservation, environmental pollution and the fact that agricultural organic wastes account for a major portion of our waste material has created renewed interest in the processing these wastes for energy recovering of several types of energy capturing process available, anaerobic digestion appears to be the most feasible for the majority of agricultural operations. Anaerobic digestion can stabilize most agricultural wastes while producing biogas or methane gas. There exist a great opportunities for exploitation of different types of biomass in Nigeria with an estimated 2.01 EJ (47.97 MTOE) bio-mass residues and wastes available to be exploited annually. The conversion of bio-mass to energy will be rewarding given the large availability of the bio-mass resources in the country. Utilization of bio-energy has not been given serious implementation attention in Nigeria as if fossil fuel will be continuing forever. It is important for Nigeria to look inward to see that the future generations will not be put at disadvantage though the continued exploitation of fossil resources by exploring alternatives energy sources . The energy challenge of Nigeria will be a thing of the past if the abundant bio-mass resources in the country is tapped and used to generate electricity. Although, there has been an upscale of activities by government towards increasing the energy mix within the country for electricity production through renewable sources. It is hoped however, that the laudable programmes and policies on bio-energy will be given some bites. The desire of the world leaders to save the ozone layer by reducing the CO_2 emission within the next few years, places an enormous expectation on the development of Renewable Energy Technology (RET).

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Reference to this paper should be made as follows: Hayatu Abba Ibrahim. (2015), Biofuel Continue to be Energy Sustenance Option for Developing Countries a Case Study of Maiduguri Metropolitan, Borno State. *J. of Engineering and Applied Scientific Research,* Vol. 7, No. 2, Pp. 20 – 34.

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