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Technopreneurship and Energy Sustainability through Biomass Gasification: A Short Review

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Abstract

A large percentage of the Nigeria population does not have access to electric energy in quantity significant enough to positively impact their life and support economic development. To augment this energy shortfall, generators powered by petroleum based fuels are used. Widespread use is limited by the increasing cost of these fuels and shrinking incomes. In addition, continuously increasing operation and maintenance costs have negatively impacted their continuous usage. In Nigeria a lot of organic waste (biomass) is generated from various agricultural activities which are the principal occupation of many in the country. These wastes could be transformed to sustainable wealth through renewable energy project as gas for fuel and electricity generation. Opportunity is therefore presented through technopreneurship to fill the energy supply gap in the country through gasification. It was a popular energy source before petroleum fuels became the preferred fuel for energy generation. This paper seeks to highlight possible ways technopreneurs in Nigeria can key into, and take advantage of the abundant biomass waste for energy supply projects that expand the country's energy mix. They are better equipped technically to select and apply the appropriate gasification technology that suits the specific needs of their communities. This approach can help bridge the power supply deficit, convert waste to wealth and conserve the environment. This paper also highlights the gains possible with biomass gasification and the need for technopreneurs to take innovative and ground breaking steps to actually implement electricity generation projects through biomass gasification.

Keywords: Technopreneurship; Technopreneur; Gasification; Biomass; Waste; Innovation.

1. INTRODUCTION

The creative application of technological skills and expert knowledge in entrepreneurship for a given technology is a necessity in order to develop and transform appropriate technologies into successful products in the market place to meet human need. Technopreneurship involves using technological know-how to satisfy market need. This can only be achieved when researchers are in touch with the market. This is the new economy driven by knowledge based on technology and innovation.

This new idea of economic and sustainable growth is one that can solve the unemployment problem and bring about global relevance and competitiveness (Omeruo, 2014). The major problems threatening world survival in the 21st century have been how to achieve economic growth, food and energy security, while conserving the environment. Inadequate capacity has been a lingering problem of power generation in Nigeria. Like other emerging economies, Nigeria is presently exploring various avenues of converting waste to wealth. This has led to a growing army of young technopreneurs - technology focused entrepreneurs (Omeruo, 2014). The future of Nigeria is gradually being shaped by the tenacity of young people who have embraced technology innovation and entrepreneurship (Omeruo, 2017).

The sustainable electricity supply has remained a hard to achieve target in Nigeria since independence. The national grid has not been able to deliver electricity sustainably to homes in urban and rural areas. Major Industrial centers have not been able to depend on the grid for their energy needs. They have invested in captive power plants that are powered by diesel engines and/or natural gas. The gas is piped to their factories by the Nigeria Gas Company. Telecom Industry has also invested in distributed power systems. Their transmitters were powered initially by diesel generators. Many of them now are bringing solar photovoltaic electricity into the energy mix to power their transmitters. Apart from the national grid managed by the Transmission Company of Nigeria which has her control centre at Osogbo, Osun state, there is an almost total absence of other transmission grids in the country.

An exception is the Nigeria Electricity Supply

Company Ltd. in Jos, Plateau State Nigeria which was established in 1925 to power the tin mines. NESCO operates a small grid that services all the former mine-field areas on the Jos, Plateau State, Nigeria in addition to its electricity generation operations. There have been reported attempts at micro grids in some rural areas. However, there is no known report of micro grids in operation in the country. The electricity supply deficit coupled with increasing uptake of modern technology and diversification of economic activities, Nigeria has become a power hungry country. The gap between supply and demand presents a serious problem that must be solved if the economic potentials of the country must be realized.

2. RENEWABLE ENERGY: BIOMASS

There is a switch to renewable power source such as solar, photovoltaic (PV), wind, biomass and hydroelectric generation. This is due to an alteration to the climate due to temperature rise caused by the greenhouse effect which poses a risk to humanity and other species (Sikarwar, 2016). Distributed energy system has been gaining popularity the world over. This has been made possible with the decreased cost of solar driven electricity infrastructure. Biomass has been often overlooked as part of the fuel for the electricity supply mix in Nigeria.

However the recent adoption of a national policy on renewable energy by the Federal Government in April 2015 has provided a road map for biomass to be an important factor in the electricity supply mix of the country. The policy seems to remove obstacles that have put renewable energy in a disadvantaged position relative other energy sources. Issues addressed in the policy are supply and utilization of renewable energy, renewable energy pricing and financing, legislation, and standards, energy efficiency and conservation, project implementation issues, research and development, capacity building and training; gender and environmental issues; planning and policy implementation(NREEEP, 2015).

Relative to other renewable resources like solar and wind, biomass has some attractive qualities favoring her adoption in Nigeria for electrical energy generation. A good proportion of the population in Nigeria subsists on agriculture. This makes biomass in the form of agricultural residue to be available all over the country. The fuel is thus available all year round, moved and stored. Biomass therefore can be a solution to the electric power shortfall in the country, particularly the rural areas.

Currently biomass provides more than 10% of the global energy supply, and ranks among the top four energy sources in terms of world final energy consumption in 2011 (Sikarwar, 2016).

In Nigeria, attention has been on hydroelectric power generation and solar electric power generation. Not much activity has been observed regarding the use of biomass for electricity generation. Biomass according to the EU and UN legal framework is a renewable energy source because plant stock can be replaced with new growth. It is most often referred to as plants or plant-based material that are not used for food or feed (https:/en.wikipedia.org/ wiki/Biomass). Biomass resources include wood fuels, residues from lumber companies, by products from crops such as forage grasses, rice husk, animal waste, and aquatic biomass (Mohammed, 2015). Large quantities of agricultural plant residues are produced annually worldwide and are vastly underutilized (Bhavanam and Sastry, 2011).

In countries like United States, the total primary energy consumption from various biomass resources is currently 4%, and there is an anticipated increase to 10% by the year 2035 (Wenjia, 2013). A major commercially successful use of biomass has been the production of substitute fuels for electricity generation, heat and transportation fuels (Basu, 2013). Woody biomass feedstock accounts for more than 50% of the total biomass source (Wenjia, 2013; NREEEP, 2015).

Energy stored in biomass may be converted to electricity by combustion of the material, anaerobic digestion or pyrolysis and gasification. Gasification of carbon-containing materials to produce combustible gas (Syngas) has been an established technology (Basu, 2013). Commercial opportunities are possible in electricity generation through biomass gasification. Biomass gasification for the purpose of this write up, entails conversion of all carbon in biomass into a convenient gaseous fuel that is used to power electricity generation systems.

3. TECHNOPRENEURSHIP IN BIOMASS GASIFICATION

Technopreneurship in biomass gasification is the active participation of technical professionals and researchers in the mobilization of the factors of production to commercialize the results of their research, designs, and production effort. This will involve bringing innovation in the process, material selection and operating parameters, reactor (gasifier) design, and the gas through these activities. To mainstream innovation in a system, a technopreneur must deliberately recognize and separate content, process, and, process skills required for the system to function and ensure that there is creative thinking and innovation at each stage (Okorie *et al.*, 2014; Putero *et al*., 2016).This can result in an increased pace for the standardization of processes.

In Electricity deprived areas in Nigeria, Prime time activities shut down with the setting of the sun. Lack of electricity does not allow for continuance of these activities. School children are not able to study, food and farm produce cannot be preserved for long periods, and public utilities cannot be extended to these areas. The circle of poverty is, thus, locked tightly. In the country-side, the result is a continued rural to urban drift. This has left many rural areas under populated. Those who remain are elderly and retirees who have come home to settle. The electricity deprived areas can begin to burgeon with economic activity if electricity becomes a regular feature in their life style.

Electricity supply means the stimulation of demand for additional goods and services for consumer use and commercial use. Home entertainment has value added to it, there is enrichment to academic life in these areas, food processing and preservation opportunities become open to more people and wastage is minimized. Technopreneurs in these localities can look at the specific biomass available in the community especially as waste and channel them to their research and develop mental work for the production of electricity. This will in turn promote waste to wealth and bring a lasting solution to the indiscriminate dumping of waste (Lai and Reddy, 2005).

4. ELECTRICITY GENERATION THROUGH BIOMASS GASIFICATION: AREAS OF OPPORTUNITY

Gasification produces syngas at temperatures of about 800°C and above. This syngas is a mixture of gases which may be:

(1) Cleaned up and used to power an internal combustion engine to drive an electric generator. The generated electricity may be given a boost using transformers and transmitted to the end users in the communities.

(2)The syngas may be burned to generate steam which is used to power turbines that drive electricity generators. The electricity may be generated in captive power plants to power a factory or a cluster of industries, and, if large enough sold to a nearby distribution network.

(3) The electricity may be used to power water pumping stations from rivers, lakes, or other natural sources to supply water in deficient communities.

Syngas for Fuelling Internal Combustion Engine Powered (ICE) Generators: The best gasifier for this process is the downdraft gasifier. The downdraft gasifier system produces very low tar syn gas which is suitable for an ICE (Basu, 2013). Tar can lead to stalled engines and eventual engine faiure.

Syngas for Powering Steam Turbines: The best design process for this purpose is the fluidized bed gasifier. The biomass is broken down to fine particulates and fed under pressure into the reaction chamber of the gasifier to produce syngas. This is then piped to the burners that power the boilers. The boilers generate steam which is used to drive the turbines which run the generators.

Syngas for Portable Water Supply: Gas is used to generate electricity solely to power water that take water great distances to urban and rural communities within the vicinity of the water supply.

Types of Gasifier

There various types of gasification systems that have been developed (Bhavanam and Sastry, 2011). Gasifier types or designs include the fixed bed (updraft or downdraft), fluidized bed. The gasification medium is generally either air, oxygen , steam.

Fixed Bed Gasifier

Updraft Design

The fixed bed updraft gasifier is considered the simplest configuration. Air flows in opposite direction to the feed. It produces a large amount of tar and pyrolysis products in the produced gas. If used for power or fuel applications, a lot of gas cleaning would be required.

Downdraft

Air and fuel flow in the same direction in this fixed bed downdraft gasifier. Product gas usually exits near the bottom of the reactor after the reduction zone. The main advantage of the downdraft gasifier is the potential for low tar gas production. The system is best suited for small scale (15 – 500 kW).

Fluidized Beds

Fluidized bed reactors contain a bed of relatively small particles of inorganic material (often sand or small diameter ceramic beads or gravel). The bed is 'fluidized' by blowing hot oxidant up from the bottom. Individual particles are lifted by aerodynamic drag, and become suspended or entrained on the gas stream at velocities for which the drag force becomes equal to or exceeds the particle weight. When fluidized, the bed behaves much like a liquid. When the bed media is hot enough, biomass is injected either into the bed and can begin to combust or gasify depending on the amount of oxygen available

Fluid bed gasifiers were originally developed for large-scale coal gasification. Advantages of fluid bed systems include: Higher volumetric specific capacity because of well-mixed, high-heat transfer and reaction rates. Larger capacities are possible. Better feedstock flexibility (can accept wider range of moisture, ash content, particle size and bulk density). Can tolerate somewhat lower ash melting points because of lower reaction temperatures (though bed will agglomerate and lose fluidization if temperature approaches ash melting point). Tar production is lower than that for updraft gasifier, but not as low as in a properly operated downdraft gasifier. Fluid bed gasifier are generally more complex than the fixed bed designs and require more precision in control of fuel and oxidant as well as higher parasitic energy load needed for fluidization.

Possible Business Models for Electricity Generation through Biomass Gasification.

These business models provide alternative business methods for the innovative deployment of biomass gasifier technology (downdraft) for electricity supply. The Business models are intended to address various impediments that may likely be encountered such as a lack of awareness and knowledge of the importance of biomass energy and energy efficiency; regulatory barriers, ways of spreading risk, and any other barriers to investing in biomass electricity projects, and promote services to justify the investment. Suggested business models include: BOOM, BOMT and BM.

Build, Own, Operate, and Maintain (BOOM): Under this model, the technopreneurs build, own, operates and maintains the power generation and distribution systems, with revenues coming from subscriber fees.

Build, Own, Maintain, and transfer (BOMT): the technopreneurs build the plant, own the plant and provide maintenance for an agreed period of time with a client, following which ownership may be transferred to the client (community, or co-operative society or other partners/investors) after having trained those who would operate the plant.

Build and Maintain (BM): The technopreneur installs the plant and provides maintenance service of the plant on behalf of the client. The plant is fully owned and operated by the client (local community/ entrepreneur) who supplies the capital.

5. PROJECT TEAM

The Model will require a project team having an integrated system of various capacity (Okorie *et al.,* 2014) and synergy at different levels (Putero *et al., 2016*). This will encourage a networking in an eco-system (Omeruo, 2017). The process will include; biomass waste collection, sorting and packaging, feeding of stock to the reactor (gasifier), and then final gasification to generate electricity (Figure 1).

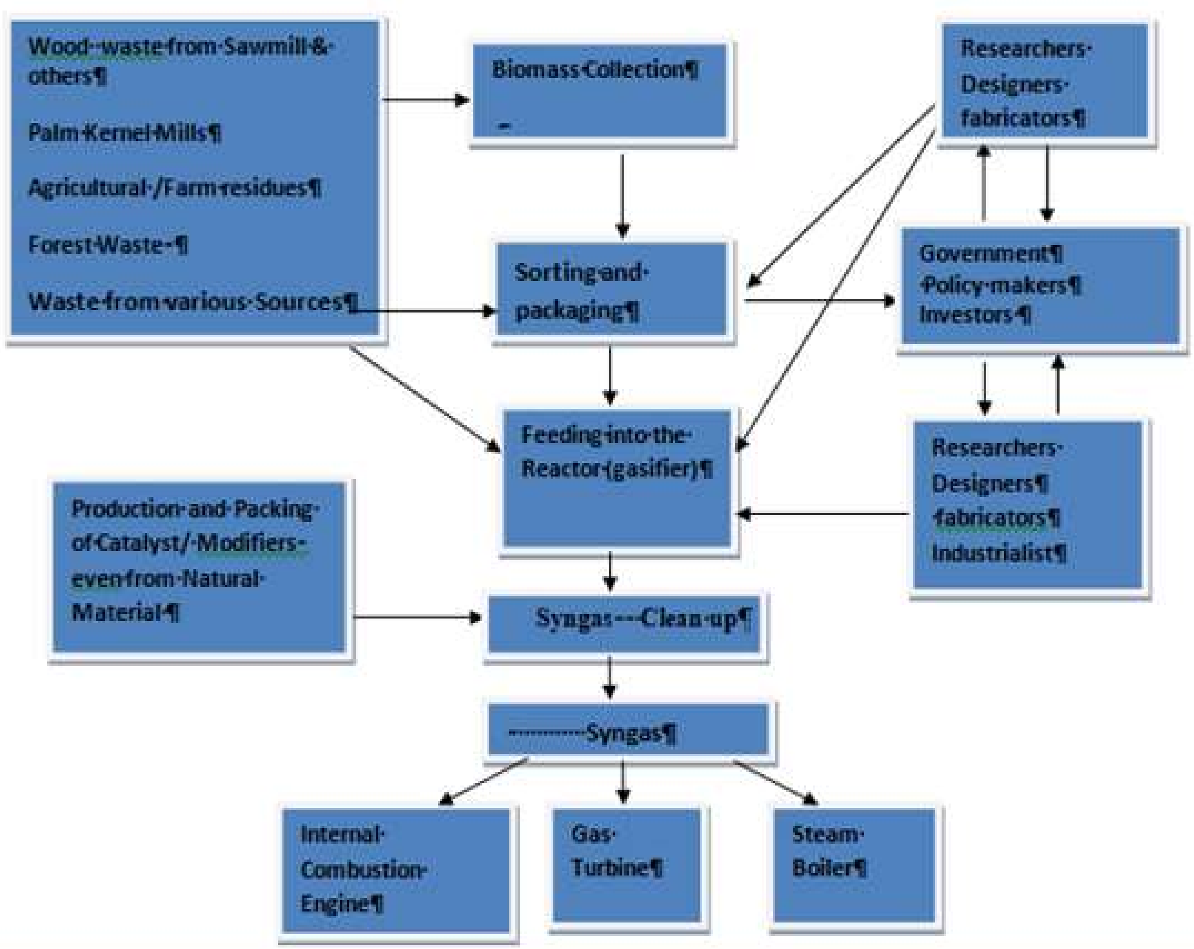

Figure 1: Electricity Generation Through Biomass Gasification.

The waste collection will be a source of environmental management system. It may require some sort of permit either from government directly or from other policy makers so that individuals that choose to get involved will work with ease. The source of collection will involve wood residue from various wood industry such as sawmills, forest waste such as abandoned felling, farm/ agricultural waste such as corn cob, rice husk, and the like, palm kernel mill waste of various forms. This will be followed by a careful sorting and packing of the collected waste to remove every material that will not favour the operation. It may also require some policy guidance for the execution of the process.

Next is the introduction of the feedstock into the designed and constructed gasifier. This may require some pretreatment such as densification for some of the biomass such sawdust, agricultural residues such as empty fruit bunch, rice straw etc.(Asadullah, 2014). It will involve the researchers; scientists and engineers, designers, fabricator, and the industrialist. This will lead to the production of gas either for steam turbine or forinternal combustion engine (ICE). ICE has less tolerance for tar and may require the introduction of catalysis in the production line to aid the production of a tar free gas.

6. CONCLUSION

Great opportunities and wealth are created through open innovation as government, the industry, the academics and the community are playing key roles to make innovation possible by adopting a vibrant ecosystem (project team) through technopreneurship which is key in achieving the global sustainable development even in the electricity sector.

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