Asian Bulletin of Energy Economics and Technology
ISSN : 2313-819X
Vol. 2, No. 1, 6-12, 2015
http://www.asianonlinejournals.com/index.php/ABEE

Biomass Energy: A Sustainable Source of Energy for Development in Ghana

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Abstract

Ghana is well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind. However, in recent times Ghana's energy sector has being bedeviled with the inability of power producers to meet demand. The current spate of power outages in the country has created anger, frustrations and demonstrations in the country. Inadequate and unreliable power supply has thus become one of the major constraints to the future economic growth of the nation. In recent times, the energy debate in Ghana has only being centered on the shortage of electricity maligning the many other forms of energy within the energy sector. This paper explores some issues on the potential development of bioenergy in Ghana as an alternative and sustainable source of energy for the country by looking at Ghana's energy situation, energy crisis, policy framework, biomass/bioenergy in Ghana, Socio-economic and environmental benefits of bioenergy and challenges to bioenergy. Ghana has significant biomass resources that provide for the majority of domestic energy use. Among the various renewable energy resources and technologies, bioenergy is the most promising. The development of biofuel may enable Ghana to achieve energy security, reduce oil import bill and save foreign exchange. It may also provide an avenue to reduce poverty and wealth creation through employment generation, increase export earning potential and finally contribute to climate change mitigation. Access to clean, modern and sustainable energy is also critical for improving the health and livelihoods of millions of people in Ghana. Bioenergy can no longer just be considered as 'the poor person's fuel' but rather be recognized as an energy source that can provide the modern consumer with convenient, reliable and affordable services.

Keywords: Biomass, Bioenergy, Energy, Renewable energy, Climate change, Ghana.

Contents

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1. Introduction

The last four decades has seen a silent revolution in the energy sector of many countries as a result of deregulation, liberalization, environmental protection and poverty reduction (Trossero, 2002). Ghana, a country on the West Coast of Africa entered into the new millennium with electricity shortages in spite of the world been endowed with a huge diversity of energy sources such as oil, gas, coal, uranium and hydropower. This is because the country's infrastructure and use of such commercial energy sources is very limited. Ghana lost about 1.8% growth of gross domestic product (GDP) in 2006-2007 as a result of an avoidable power crisis in the country (World Bank, 2013). Since 2000, much of sub-Saharan Africa including Ghana has experienced rapid economic growth. As such the energy demand in sub-Saharan Africa grew around 45% from 2000 to 2012, accounting for 4% of the global demand (IEA, 2014). Africa is believed to have huge renewable energy potential to cover the energy needs of the continent as it has six of the world's sunniest countries on earth in its continent (Abubakari, 2015). In spite of this potential, more than 620 million people (two-thirds of the population) in sub-Saharan Africa are without access to electricity (IEA, 2014). Traditional sources of energy in the form of firewood and charcoal account for over 80% of the total energy use in sub-Saharan Africa (Monforti, 2011). In sub-Saharan Africa, only 17 percent of the population have access to modern fuels (Adam *et al.*, 2013). The usage pattern of energy in Ghana is similar to that of many developing countries, with traditional fuels such as firewood and charcoal providing the bulk of energy for cooking (Adam *et al.*, 2013). Worldwide experience has shown that a well-functioning power sector is essential for rapid economic growth and improvements in the quality of life of the people of any country (World Bank, 2013).

Energy has being described as both an engine of development and a source of many of the economic and environmental problems of the world. Inadequate and unreliable power supply is one of the three major constraints to the future economic growth of Ghana (World Bank, 2013). Clean and affordable energy services are not only essential for a sustainable society but also for poverty alleviation (Remedio and Domac, 2003). Whiles Ghana's energy sector has been bedevilled with the inability of power producers to meet demand. The current spate of power outages in the country has created anger, frustrations and demonstrations in the country. Ghana's energy (power) problems and their solutions have been extensively studied by the World Bank, the US government and others. Nonetheless, there seem not to be decisive and timely decision making from the governments of Ghana to break the cycle of reactive measures that often come too late, when proactive measures would have led to better outcomes (World Bank, 2013). Low incomes, coupled with inefficient and costly forms of energy supply, make energy affordability a critical issue in Ghana. The development of Ghana's energy system in the context of energy security will rely on energy efficiency and expanded renewable energy. The present worldwide interest in renewable energy in general and bioenergy in particular is as a result of a combination of environmental considerations, social factors, the need to find new alternative sources of energy, political necessities and rapidly evolving technologies which is opening up new opportunities for utilizing bioenergy in an increasingly environmentally conscious world.

The present power shortages, arising from a cut-off of imported gas from Nigeria, could have been mitigated if Ghana's own gas from the Jubilee field had been developed on time (World Bank, 2013). Just five years after the last power crisis, Ghana has found itself in another power shortage which could have been avoided if lessons from the past had been learned. In recent times, the energy debate in Ghana has only being centered on the shortage of electricity maligning the many other forms of energy within the energy sector. Ghana's major source of energy is not electricity or petroleum; it is traditional fuels, including wood, charcoal, crop residues, and other biomass resources (USAID, 1999). This paper explores some issues on the potential development of bioenergy in Ghana as an alternative and sustainable source of energy for the country.

1.1. Ghana's Energy Situation

In 2013, the global energy demand increased by 2.5%, with fossil fuels accounting for 81.6% of global energy production whiles biofuels with a 2.8% increase, kept 10% share of global energy production mainly due to the large part of solid biofuels, (fuelwood, agro-residues) (IEA, 2015). From the globe, Africa produced 8.3% of the world's energy. Africa's production was dominated by oil (38%), followed by traditional biomass (32%), natural gas (15%) and coal (14%). The production and consumption of biofuels (mainly fuelwood) was significantly higher across Africa (48% of total TPES) than the world average (10% of total TPES) (IEA, 2015). The high biofuel consumption is attributed to the presence of large forests, agro-industry, agriculture, a large rural population, and a low GDP per capita resulting in a large use of solid biofuels for cooking (IEA, 2015).

Historically, Ghana has relied on its hydro assets; however in recent years the hydro has been complemented by fossil fuel generation to meet the rapidly growing demand. The demand for electricity in Ghana has increased in the past years as the population has grown so much and the need to meet the rising demand has become eminent. The available energy options for Ghana are;

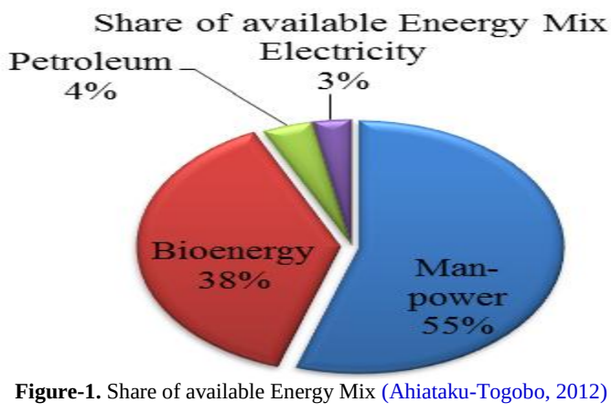

Figure-1. Share of available Energy Mix (Ahiataku-Togobo, 2012)

Petroleum Products, Electricity, Bioenergy and Man-power all for transport, ploughing, mining, fishing, milling, lighting, cooking, heating, manufacturing, brewing and electricity generation (Ahiataku-Togobo, 2012). Used mainly for cooking in the traditional inefficient ways, biomass energy consumption in the form of wood fuel is twice as large as other energy sources, including electricity and petroleum (Energy Commission, 2010).

Ghana's energy generation capacity that was available for grid power supply in 2014 was 2,831 Megawatt (MW) whilst the generation was 12,963 GWh consisting of 64.7% hydro, 34.75% thermal and 0.05% solar power (Energy Commission of Ghana, 2015a). Ghana's annual electricity consumption per capita since 2010 has been below 400 kWh less than the global minimum average of 500 kWh for lower middle-income developing countries (ECG, 2015a). In terms of primary energy supplied in 2014, 3,628 ktoe (39%) was from wood fuels, 4,177 ktoe (46%) from oil, 621 ktoe (7%) from natural gas, and 721 ktoe (8%) from hydro. The total energy supplied was 9,147 ktoe, which is equivalent to 0.34 ktoe per capita. The country primary consumption for the same year was 7,016.4 ktoe, representing 0.26 ktoe per capita with 3,271.7 ktoe (47%) petroleum, 2,791.7 ktoe (40%) biomass and 953 ktoe (13%) electricity (ECG, 2015b).

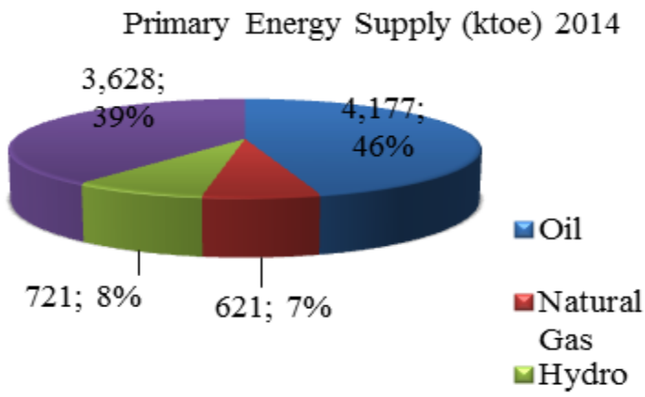

Figure-2. Primary Energy Supply (ktoe) for 2014 (ECG, 2015b)

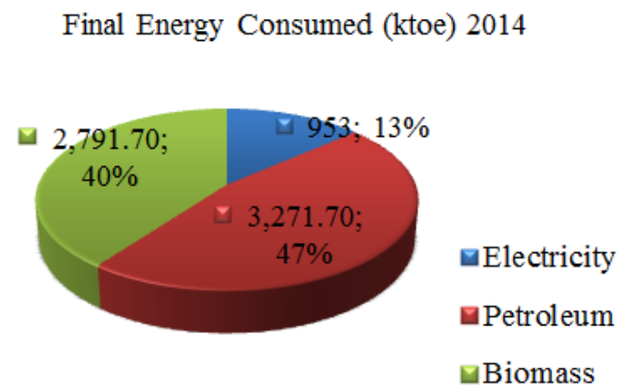

Figure-3. Final Energy Consumed (ktoe) for 2014 (ECG, 2015b)

1.2. Ghana's Energy Crisis

Ghana has had electricity crises before, with the present power shortages arising from a cut-off of imported gas from Nigeria. Ghana is currently going through its fourth electricity crises after independence. With the exception of the early days of the Akosombo project when the peak demand for Ghana was 100 MW, less than 20 percent of the installed capacity that Ghana enjoyed a relatively long era of abundant, economic hydropower (USAID, 1999) there had been a fundamental problem afterwards; demand for energy has been consistently greater than supply. The first crisis was in 1983-1984 whiles the second came in 1994-1997 all as a result of erratic rainfall in the Volta Basin (USAID, 1999). The third crises came in 2006-2007 as a result of poor rainfall resulting in reduced inflow into the Volta Lake and the non-availability of sufficient reliable thermal power generators at the Aboadze power plant to complement the reduced generation from Akosombo and Kpong. The present crises which has being code named "Dumsor" started from 2012 as a result of multi-dimensional reasons amongst which are the cut-off of natural gas supply from Nigeria to Ghana, poor rainfall resulting in reduced inflow into the Volta Lake, lack of funds for fuel procurement and major maintenance works on the thermal plants. Economic growth together with increasing rates of industrialisation and urbanisation has led to accelerated power demand in Ghana. Key problems in the sector include demand outstripping supply, poor state of transmission and distribution, and tariffs that do not cover costs. In addition, the existing power plants are not able to attain full generation capacity due to fuel supply constraints and uncertainty of rainfall and water inflows into the hydroelectric power facilities (Gyamfi *et al.*, 2015).

1.3. Policy, Legal, And Regulatory Framework of the Energy Sector in Ghana

In terms of legislation and regulations, there are a lot of laws and policies that have been put in place to support the energy sector. In 1997, the Energy Foundation was established to promote energy efficiency and renewable energy as a key strategy to managing Ghana's growing energy needs in a sustainable manner (USAID, 1999; Energypedia, 2015). The Energy Commission (EC) was also established in 1997 by the Energy Commission Act (Act 541) to provide technical advice to the Ministry on regulating, managing, developing, and utilizing energy resources in Ghana (Energy Commission Act, 1997). Ghana also enacted the Public Utilities Regulatory Commission (PURC) Act (Act 538) responsible for regulating electricity and gas tariffs and enforcing customer service obligations of all public utilities (Public Utilities and Regulatory Commission Act, 1997; USAID, 1999; Energypedia, 2015). The Ministry of Energy (2010) outlines the Government's policy direction for the energy sector. The Energy Sector Strategy and Development Plan (MoE, 2010) also covers the Government's strategies, program, and projects for developing the; Energy Sector Institutions, Power Subsector, Petroleum Subsector, Renewable Energy Subsector, Waste-to-Energy, Energy and Gender (MoE, 2010; Energypedia, 2015).

The renewable energy policy of the Economic Community of Western African States (ECOWAS) is a regional document that calls for achieving renewable energy targets of 19 percent of installed capacity and 12 percent of generation by 2030. The Sustainable Energy for All (SE4All) program is focused on improving access to modern fuels for cooking and productive uses of energy in Ghana through investments in LPG infrastructure and subsidizing distribution of LPG cylinders as well as introducing improved biomass cook stoves, marketing improved biomass cook stoves, and investing in small and medium sized enterprises that will manufacture improved cook stoves (United Nations, 2012; Energypedia, 2015). The Volta River Development Act, 1961 (Act 46) (the "VRD Act") established the oldest power entity in Ghana: the Volta River Authority ("VRA") with the purpose of generating electricity by means of the water power of the Volta River and by any other means. The Bui Power Authority Act,

2007 (Act 740) (the "Bui Power Act") established the Bui Power Authority to oversee the development of a particular hydroelectric power project on the Black Volta River at Bui and any other potential hydroelectric power sites on the Black Volta River (Energypedia, 2015).

The Renewable Energy Act (2011) aims to support the use of renewable energy technologies to increase generation of electricity, diversify supply of electricity and generates electricity in an environmentally sustainable manner (REA, 2011). The National Electricity Grid Code (Grid Code) of Ghana establishes the requirements, procedures, practices, and standards for developing, operating, maintaining and using the National Interconnected Transmission System (NITS) (World Bank, 2013; Energypedia, 2015). These laws, policies, and regulatory institutions are important precursors on the road to reaching Ghana's energy goals and economic freedom. However, by themselves they are not sufficient (USAID, 1999).

1.4. Biomass / Bioenergy in Ghana

Ghana is relatively well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind (United Nations, 2012). Biomass in the form of wood is the oldest form of energy used by humans (Demirbas, 2009). Energy in all its forms can be broadly classified as either renewable or non-renewable. Renewable energy is a form of energy capable of being regenerated by natural processes at meaningful rates. Biomass, sunlight, wind, flowing water, heat within the Earth's crust and tides are some renewable energy resources. Non-renewable energy, on the other hand, is finite. It cannot be regenerated in a timely fashion by natural processes. Coal, oil, natural gas, tar sands, oil shale, and nuclear energy are all non-renewable forms of energy (Chiras, 2006). The term 'biomass' refer to mass of organic material which comprises all forms of life, dead organisms and organic metabolism products (Quaschning, 2010). Bioenergy on the other hand is an inclusive term for all forms of biomass and biofuels (Demirbas, 2009). Bioenergy is a renewable source of energy that makes use of biomass to produce energy. Africa has abundant biomass often referred as "the green gold" of Africa; however the resource is mostly used to a large extent in an inefficient way (Monforti, 2011). Nearly 730 million people in sub-Saharan Africa rely on the traditional use of solid biomass for cooking (IEA, 2014). Around 10% of the world's primary energy is made up of biofuels used in developing countries. In these countries, biofuels are used very inefficiently and in very polluting ways which expose hundreds of millions of women and children to indoor air pollution from cooking and heating (Remedio and Domac, 2003). Each year nearly 600,000 premature deaths in Africa can be attributed to household air pollution resulting from the traditional use of solid fuels, such as fuel wood and charcoal (IEA, 2014).

Among the various renewable energy resources and technologies, bioenergy is the most promising for developing countries as its mobilization can provide large employment generation schemes, and can be directly linked to ecosystem conservation and even rehabilitation (Remedio and Domac, 2003). Brazil was the first developing country to pioneer the development of bioenergy as a local energy solution whiles developed countries like Austria, Canada, Finland, Germany, the Netherlands, Sweden and the United States have also adopted new energy policies with an increased utilization of wood energy within their energy mix (Trossero, 2002). Biomass energy continues to be the main source of energy in many developing nations, particularly in its traditional forms, providing some 35 percent of the energy needs of three-quarters of the world's population (Rosillo-Calle, 2007). The most important biomass energy sources are wood and wood wastes, agricultural crops and their waste by-products, MSW, animal wastes, waste from food processing, and aquatic plants and algae (Demirbas *et al*., 2009). Biomass is an energy carrier which needs to be converted into a form that is convenient for transport and use. Biomass can be transformed into both heat and electricity simultaneously or separately, into transport fuels and even into petrochemical substitutes (Remedio and Domac, 2003).

Wood-based fuels remain the dominant source of energy for over 2billion poor people in developing countries and in most of these countries, wood fuels are not only vital to the nutrition of the rural and urban households, they are also often essential in food processing industries for baking, brewing, smoking, curing and electricity production (Trossero, 2002). Biomass remains the most used fuel for cooking in Ghana with wood being the most preferred in the rural areas (Mohammed *et al.*, 2013) whiles charcoal and gas are predominantly used in the urban areas of the country (Adam *et al.*, 2013). Biomass is also the main source of energy for many of the poor in Ghana (Adam *et al.*, 2013). Presently the state is actively encouraging investment in biofuel development to achieve energy security and independence. Investments in biomass energy can be an effective tool to combat desertification as well as significantly impact on global climate change. Access to clean; modern, sustainable energy is critical for improving the health and livelihoods of millions of people in Ghana. Ghana has the capacity to increase its cassava and palm oil production in order to introduce liquid biofuels in its energy mix within three years and these feedstock productions could be achieved by improving on their cultivation methods (Afrane, 2012). Biomass in all its forms has been the most important source of the seven basic needs (the seven 'fs'); food, feed, fuel, feedstock, fibre, fertilizer and finance for man throughout human history (Rosillo-Calle, 2007).

Access to modern forms of energy on sustainable basis is vital to unlocking for the faster economic and social development of Ghana. In Ghana, the goal of Government concerning bioenergy is to modernize and maximize the benefits of bioenergy on a sustainable basis. As such the policy objectives of Government's biofuel development program is to substitute national petroleum fuels consumption with biofuel by 10% by 2020 and 20% by 2030 (Energy Commission, 2010; MoE, 2010). There are significant amounts of biomass resources available in the country that can provide a reasonable amount of energy (Mohammed *et al.*, 2013). The development of biofuel may enable Ghana to achieve energy security, reduce oil import bill and save foreign exchange. It may also provide an avenue to reduce poverty and wealth creation through employment generation, increase export earning potential and finally contribute to climate change mitigation (Energy Commission, 2010; MoE, 2010; Iddrisu and Bhattacharyya, 2015). The trend in the supply and consumption of energy in Ghana from 2005 to 2014 are depicted in Figures 4 and 5 respectively.

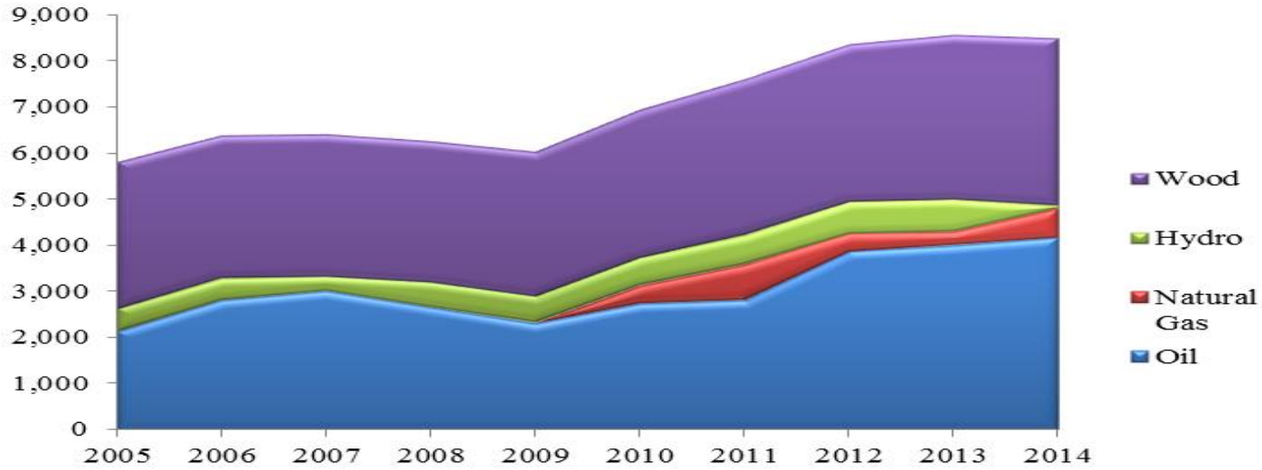

Figure-4. Trend in Primary Energy Supplied (ktoe) from 2005-2014 (ECG, 2015b)

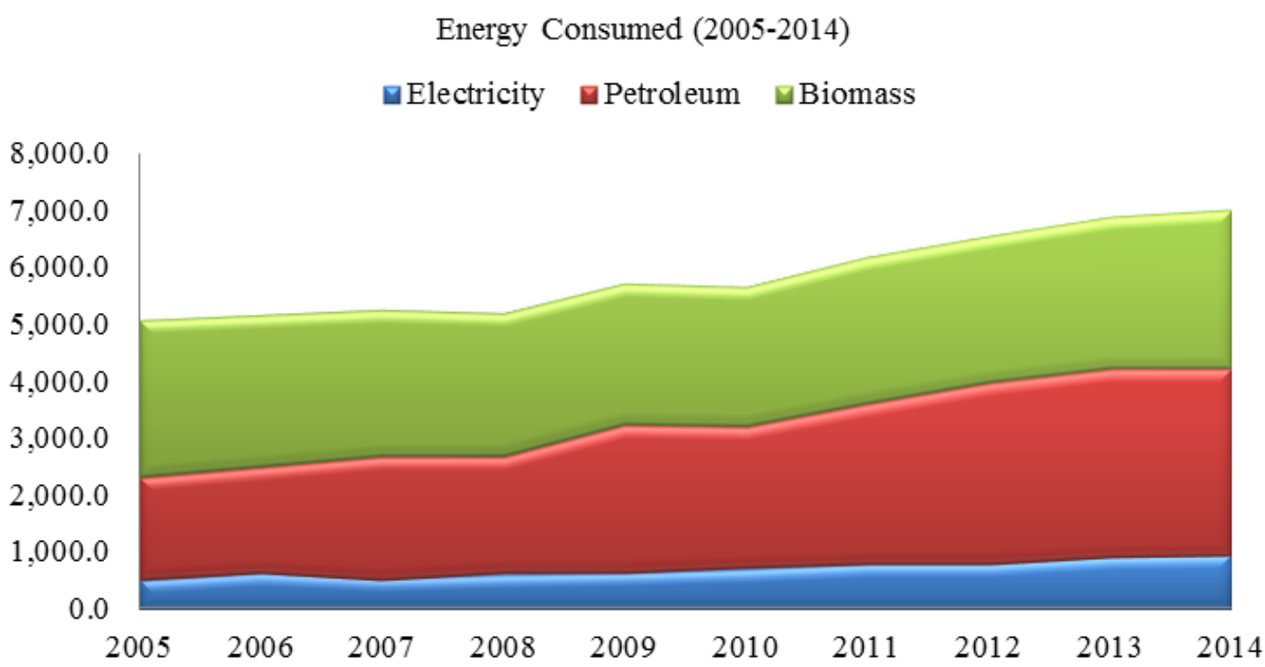

Figure-5. Trend in Final Energy Consumed (ktoe) from 2005-2014 (ECG, 2015b)

There is a great potential for bio energy since there are a variety of biomass resources in the country. Among the renewable energy sources, bioenergy has a great potential of improving the energy security of the nation. Bioenergy can no longer just be considered as 'the poor person's fuel' but rather be recognized as an energy source that can provide the modern consumer with convenient, reliable and affordable services (Remedio and Domac, 2003). Bioenergy can sustainably contribute between a quarter and a third of global primary energy supply in 2050 (IEA Bioenergy, 2009). Additionally, bioenergy is the only renewable source that can replace fossil fuels in all energy markets in the production of heat, electricity, and fuels for transport (IEA Bioenergy, 2009).

1.5. Socio-Economic and Environmental Benefits/Potential of Bioenergy in Ghana

Ghana lost about 2% of GDP in 2014 due to the power crisis (ECG, 2015b). About 1000 workers were also laid off by their employers between December 2014 and end of first quarter 2015 due to low industrial output as a result of inadequate power supply (ECG, 2015b). Real GDP growth declined from 8.8% in 2012 to 7.1% in 2013 and 4.2% in 2014. It is further projected to decrease to 3.5% in 2015 due to the worsening power crisis and fiscal consolidation (ECG, 2015b). This undoubtedly proves that stable and sufficient electricity supply is a key input to firm growth, expansion and development. There is growing evidence linking socioeconomic benefits with access to a reliable and affordable supply of electricity. Inadequate access to energy also exacerbates rapid urbanization in developing countries, by driving people to seek better living conditions (United Nations, 2012).

Bioenergy continues to provide a significant amount of global consumer energy. Modern biomass usage result in health benefits as a result of better wood stove design for people living in rural areas when biomass replaces coal and reduced pollution by those living in urban centers using biofuels (Remedio and Domac, 2003). Bioenergy indirectly contribute to alleviating poverty by providing energy for cooking, space heating and lighting and directly by providing the energy needed for creating businesses and employment (Abubakari, 2015). Biofuels are unique for developing economies as they are tied to agriculture and therefore their raw material needs can be met locally (Afrane, 2012).

In Ghana, biomass could boost agricultural development and technological advancement and further bring opportunities like releasing women and children from collecting fuel and creating new employment, in so doing improves the quality of life (Mohammed, 2007). Biomass is also an important source of income during the off-harvest season (Remedio and Domac, 2003). According to the IPCC (2012) access to clean and reliable energy

constitutes an important prerequisite for fundamental determinants of human development, contributing to economic activity, income generation, poverty alleviation, health, education and gender equality. There is also a direct relationship between the absence of adequate energy services and many poverty indicators such as infant mortality, illiteracy, life expectancy and total fertility rate (United Nations, 2012).

When biomass resources are produced locally, it reduces the country's dependence on foreign energy sources, and vulnerability to supply disruptions (Mohammed, 2007). Biomass resource cultivation, harvesting, and processing at the local level could have a direct impact on rural development that could improve rural livelihoods by providing new income opportunities to the families. Using biomass to produce energy is carbon-neutral because it releases roughly as much carbon dioxide (CO_2) as it takes in. Thus biomass absorbs CO_2 during growth, and emits it during combustion. Reducing CO_2 emissions as well as cutting the cost of climate change mitigation can increase both GDP and employment in Ghana. In addition, adopting low carbon technologies will accelerate sustainable development in developing countries (Abubakari, 2015). With the abundance of cheap agricultural and forestry wastes, biomass sustainability may allow a nation like Ghana to be energy independent and this would lead to reallocation of resources in budgets to other areas of concern.

1.6. Challenges to Biomass/Bioenergy in Ghana

Ghana has significant biomass resources that provide for the majority of domestic energy use. These resources present both opportunities and risks for the energy sector development in Ghana. One major energy challenge is how to reduce dependence on biomass and manpower in favour of modern energy (Ahiataku-Togobo, 2012). Over reliance on wood fuel is also accelerating the rate of depletion of Ghana's forests (Energy Commission, 2010).When biomass resources are properly managed, they provide clean and sustainable sources of energy. On the contrary if they are poorly managed they become an exhaustible natural resource (Energy Commission, 2010). Despite the fact that biofuel holds the potential to reduce dependency on petroleum and reductions in net Green House Gas (GHG) emissions, their cultivation also poses a challenge to sustainable agricultural practices and the food-fuel balance (Energy Commission, 2010).

The situation where certain crops such as palm fruit are used for biofuel production is seriously contributing to food shortage on the global market and as such the use of land for biofuel crop cultivation should be regulated to avoid the use of fertile land for food crop cultivation. Another risk of biofuels is the potential for fuel crops to be grown on ecologically fragile lands that could accelerate soil erosion and the depletion of aquifers (Hunt, 2007). Additionally, biofuel crops could destroy some of the world's remaining tropical ecosystem that is home to vast treasures of biodiversity (Hunt, 2007). There is also no adequate capacity in engineering, science and technology to develop and sustain a vibrant biofuel industry. Along with the low capacity is the lack of the needed conversion technologies and their appropriate equipment. The few research and educational institutions are not well equipped and resourced to undertake specialized engineering research and development in biofuel production and their equipment.

2. Conclusion

Currently, global climate change and its catastrophic impacts like devastating drought, more violent storms, and severe water shortages are some of the reasons why Ghana must give priority to renewable energy in general and for that matter bioenergy in particular. As a country and a people, in our quest for a better, brighter energy future, we should have in mind that there is much we can do to improve energy efficiency in our homes. We can improve energy efficiency without sacrificing services we so desire. Similarly renewable energy resources are vast in our country that can provide the energy needs of the people especially those in rural areas. As at now, the available energy options for Ghana are; petroleum, electricity, bioenergy and man-power. This paper explored some issues on the potential development of bioenergy in Ghana as an alternative and sustainable source of energy for the country.

Ghana is well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind. Biomass remains the most used fuel for cooking in Ghana with wood being the most preferred in the rural areas whiles charcoal and gas are predominantly used in the urban areas of the country. Biomass is also the main source of energy for many of the poor in Ghana. Bioenergy is a renewable source of energy that makes use of biomass to produce energy. With the abundance of cheap agricultural and forestry wastes, biomass sustainability may allow a nation like Ghana to be energy independent and this would lead to reallocation of resources in budgets to other areas of concern. Bioenergy has a great potential to provide greenhouse gas savings and other environmental benefits and also contribute to energy security, improve trade balances, provide opportunities for social and economic development in rural communities, and improve the management of resources and wastes. When developed in a sustainable way, bioenergy has the potential to produce both electricity and fuel with fewer risks than those associated with oil, coal, and nuclear technologies. Bioenergy is thus no longer just 'the poor person's fuel' but rather a recognized energy source that provide the modern consumer with convenient, reliable and affordable services.

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