

UTILIZATION OF SOLAR AND BIOMASS ENERGY- A PANACEA TO ENERGY SUSTAINABILITY IN A DEVELOPING ECONOMY

P.A. Nwofe

Division of Materials Science and Renewable Energy, Department of Industrial Physics, Ebonyi State University, Abakaliki, Nigeria.

ABSTRACT: *This study presents the potentials of solar energy utilisation and other possible pathways that could enhance energy sustainability in a developing economy. Nigeria is a developing country, blessed with abundant natural resources (renewable and non-renewable). However the current energy mix in Nigeria is such that little attention is given to the renewable sources in terms of exploitation and use. Despite the on-going privatisation of the Power Holding Company of Nigeria (PHCN), the current energy demand in Nigeria still far outweighs the supply which is also quite epileptic. The adoption of renewable energy options especially solar-thermal, solar photovoltaics, and biomass technology on a large scale will surely lead to reduced internal consumption of fossil fuel related products, and to boost increased energy availability and sustainability. This study critically examines the factors hindering solar and biomass energy utilisation in a developing economy. It then identifies the impact of unsustainable energy use in the economy and reviews related literature. It also highlights the need for Government to give urgent attention to tapping of the vast renewable resources in the country for increased energy generation and sustainability.*

KEYWORDS: Solar energy, energy sustainability, developing economy, renewable energy, utilisation.

INTRODUCTION

Most developed economies rarely rely on a single source of energy generation for her energy needs. Nigeria is a developing economy. It has a land mass of 923,768 sq.km, is located in West Africa in the tropical region with latitude 10.0N and longitude 8.00E (Menakaya and Floyd, 1980). It has been reported that the annual total solar radiation on average, varies from about 12.6 MJ/m²/day (3.5 kWh/ m²/day) in the coastal latitudes to about 25.2 MJ/ m²/day (7.0 kWh/ m²/day) in the far north (Nwulu and Agboola, 2011., Oseni, 2012., Oji et. al., 2012., and Oyedepo, 2014). This translates to an average annual solar energy intensity of 1934.5 kWh/m²/yr, implying that an average of 6,372,613 PJ/year (\approx 1,770 thousand TWh/year) of solar energy falls on the entire landmass area of Nigeria within one year. In the south-east states, research work by

Nwankwo et. al., (2012) indicate that the maximum solar irradiance is in the range 895.70 W/m² to 1043.83 W/m². It has been reported that south-west Nigeria, which lies on latitude 7.5°N has a

mean irradiance of 22.4 MJ/m² per day for the month of April (Awogbemi and Asaolu, 2008). This clearly points to the huge energy reserves that could be tapped from the sun in Nigeria and an indicator that the scale of renewable energy potential is much larger than the public or policymakers estimate. It has been shown recently that concentrated solar thermal power potential in Nigeria is over 427,000MW (Ogonmodimu and Marquard, 2013). Reports indicate that the per capita power consumption in Nigeria is estimated at 82 KW whereas South Africa has a per capita consumption of 3793 KW (Nwulu and Agboola, 2011). Iseleorunkami (2014) noted that Nigeria's electricity consumption on a per capita basis was among the lowest in the world when compared with the average per capita electricity consumption in countries like Libya, India, China, South Africa, Singapore, and the United States. Most recently, Anyanrouh in Vanguard (February 26, 2013) reported that the per capita power consumption of Nigerians is at 106.21 KWh per head, which is far below what is obtained in other developing countries like Gabon (900.00 KWh); Ghana (283.65 KWh); Cameroon (176.01); and Kenya (124.68 KWh). It has been argued that despite the privatisation of PHCN in 2013, Nigeria's electricity generation capacity has plummeted from the peak generation level of about 4,517.6 megawatts (MW) recorded in December, 2012 to about 3,670 MW in January, 2014. Also the electricity generation forecast was 12,800 MW of electricity, energy generation capacity at 3,670 MW hour per hour (MWH/H), while actual electricity delivered into the national grid was 3,585.32 MWH/H (Obasi and Ayansina, 2014., nigeriapowerreform.org).

Nigeria also has vast biomass resources that are left untapped at the moment. The volume of wastes generated in Nigeria on daily basis is quite enormous and these wastes are not utilised in a sustainable manner. It has been established that the generation rate of solid wastes in the capital cities of some south-east states (Ebonyi and Imo) is in the range 9.580 to 9.74 x 10⁻³ m³ (Nwofe, 2013., Nwoke, 2013). The waste density of municipal solid waste in Nigeria ranged from 280 to 370 kg/m³ with the waste generation rates in the range 0.44 to 0.66 kg/capita/day (Ogwueleka, 2009). Ngumah et. al., (2103) noted that Nigeria generates about 542.5 million tons of organic waste which has the potential of yielding about 25.53 billion m³ of biogas (about 169 541.66 MWh) and 88.19 million tons of biofertilizer, with an estimated revenue generation of about N 4.54 trillion (\$ 29.29 billion) from both ventures. Waste disposal in Nigeria is still done by very crude and primitive methods. This has been discussed by various authors (Elom, 2013., Nwofe, 2013., Uzoma, et. al., 2012., Ohakwe, 2011., and Ogbonna, 2011). Wastes from the agricultural sector accounts for a reasonable percentage of waste in Nigeria, with open dumping as one of the major modes of waste disposal (Olorutande, et. al., 2013). Reports indicate that Nigeria ranks number 8 in the world in methane emission with about 20 billion m³ of methane emission (13% of world emission), and 69% of Nigeria's methane emission actually emanating from gas flaring while 28.8% originates from untreated organic wastes (www.factfish.com). It has been established that waste management has a sustainability goal to generate enough energy to power more than 2 million homes by the year 2020 (Scheutz et. al., 2009). Nigeria total energy consumption is 1,259 TWhr per annum with a total electricity production of 19.78 TWhr per annum (www.power.gov.ng). Research done by Onakoya et. al., (2013) indicated that a direct and positive relationship exist between Nigeria's economic growth and the variables; total energy consumption, petroleum consumption, gas consumption, electricity consumption, and coal consumption. Ezennaya et. al., (2014) and Onakoya et. al., (2013) also identified increased energy consumption as a strong determinant of economic growth in Nigeria. Most developing economies are saddled

with problems of insufficient energy for her citizenry as is the case for Nigeria, Ghana, Kenya, Gabon to mention but few. Sustainable energy development in Nigeria is a fundamental step towards achieving stability in the; economy, social order, agriculture, politics, industry and increased bilateral and multilateral trade with other nations. This paper aims to identify/discuss;

- (i) utilisation of solar and biomass energy,
- (ii) factors hindering large scale utilisation of these resources,
- (iii) effects of unsustainable energy use, and
- (iv) recommend possible solutions.

UTILISATION OF SOLAR AND BIOMASS ENERGY IN NIGERIA

The potentials of solar and biomass energy has been established by various authors in the literature. However, utilisation of solar and biomass energy is still at a very small scale. It was just recently that solar PV devices penetrated the Nigeria market though the high cost of these devices still limits its consumption to the super-rich/ upper class citizens. Solar energy is used in Nigeria mostly in agriculture for; open crop (yam, cassava, okra, maize, beans, rice, soya beans, etc) drying, solar crop dryer, poultry production, chick brooding, chicken growing, solar manure drying, swine production, and in diary production. It is also used for solar PV for rural electrification, solar water pump, and solar water heaters. Research done by Yohana and Umogbai (2010), and Ilenikhena and Ezumonye (2010), indicated that it is only in agriculture that solar energy is mostly utilised both by rural and urban dwellers though at a small scale. Also very few social and health institutions use solar energy for domestic water pumping and in solar fridges for vaccine storage, and most recently as building integrated photovoltaics (BIPV) and street lights by Governments (on very small scale).

Biomass energy is mostly utilised in the most primitive and ancient methods in Nigeria. Fuelwood still constitutes the major source of cooking fuels for the rural and even urban dwellers. It has been established that Nigeria contributes about 10 percent global annual deaths from smoke related illness caused by indoor and outdoor pollution due to overdependence on biomass for cooking fuels (Newsom, (2012)., and Nwofe, 2013). Research done by Poopola et. al., (2013) highlighted the potentials of waste-to-energy system in Nigeria by considering the potential of bio-oil production from wood residue generated in major cities of south-western Nigeria. Recently, the Federal Ministry of Environment launched the National Clean Cooking Scheme, aimed at eliminating or reducing the over dependence on fuel wood for cooking since over 70 percent of rural population in Nigeria depends on biomass for her domestic energy needs. In Nigeria currently, waste is sustainably managed in Lagos State only. Lagos Waste Management Authority (LAWMA) is working hand-in- hand with the Federal Ministry of Environment to reduce the effect of short-lived climate pollutants (SLCP) and other associated hazards from the municipal solid waste sector. It is only in Lagos state that waste to energy is functioning. It has been reported that the Federal Ministry of Environment in liason with LAWMA have established various landfills/dumpsites; Lagos Olusosun, Solous, Ewuelepe, and Epe, where waste materials (domestic, commercial, industrial, and medical) generated in Lagos State amounting to 7000 tonnes are received on daily basis (www.unep.org, Tobore, 2012).

SOLAR ENERGY PROJECTS IN NIGERIA

Based on the 1999 national survey by the Nigeria Energy Commission, there are a total of 33 companies that were active in Solar PV by then, with over 200 solar PV installations, in the country as at 1998, with capacities ranging from 3.5 to 7.2 kWp (Energy Commission of Nigeria). The Solar Electric Light Fund (SELF), an NGO based in USA. Jigawa State Government initiated a proposal to bring solar-generated electricity (PV) to power essential services in 3 villages of Jigawa State in 2001 (Chendo, 2002). Research done by Awogbolomi and Komolafe (2011), indicated notable solar energy projects in Nigeria to include:

- (i) Street lighting in Ado Ekiti, Ekiti State,
- (ii) 7.2kWp Kwalkwalawa Village Electrification, Sokoto State,
- (iii) 1.87kWp Iheakpu-Awka Village Electrification/TV Viewing, Enugu State,
- (iv) 1.5kWp Nangere Water Pumping Scheme, Sokoto State,
- (v) 2-tonne Solar Rice Dryer, Adani, Enugu State, and
- (vi) 1.5-tonne Solar Forage Dryer, Yauri, Kebbi State.

Other new investment in the solar energy sector in Nigeria include;

- (i) 50 MW solar farm in Kaduna State by the Synergent Group,
- (ii) 100MW solar farm in Bauchi State by the Nigeria Solar Capital Project and Gigawatt Solar,
- (iii) 60MW in Katsina State by the Nigeria-German Energy Partnership,
- (iv) 20MW solar energy plant owned by Katsina State,

These projects are aimed at reducing the acute energy poverty in Nigeria, reduce green house gas emission from use of diesel generators, and enhance sustainable energy use in Nigeria. In 2013, President Goodluck Jonathan inaugurated the “Light-Up Rural Nigeria” in Durumi Community, Bwari Area Council, Abuja with the intent that renewable energy will be used to generate electricity for rural communities, especially areas not connected to the national grid in all the 36 states of the federation (Premium Times, 2013). It was reported recently that SkyPower FAS Energy has entered into agreements with both the Federal Republic of Nigeria Government and the Delta State Government for the setting up of utility-scale solar photovoltaic (PV) projects totaling 3,000MW within Nigeria and Delta State (www.powertechnology.com). The project is set to be developed within five years and will lead to the production of clean, sustainable and cheap electricity that will meet the growing energy needs of Nigerians.

BIOMASS ENERGY PROJECTS IN NIGERIA

The use of biomass energy is yet to attain widespread technological growth in Nigeria. However some pilot projects aimed to educate and ensure availability of improved wood stoves to Kwara and Awka-Ibom States were contained in the 2012 budgetary allocation (www.unep.org). Some biomass energy projects in Nigeria includes (www.renewableenergy.gov.ng, Tobore, 2012);

- (i) Epe Integrated Solid Waste Management Project in Lagos State,

- (ii) Gas to Energy Projects at Olushosun landfill site in Lagos State,
- (iii) Biofuel Production Complex at Ilemeso in Ekiti State and other States that lie between latitudes 7° and 14°N (Ondo, Kwara, Osun, Oyo, Kogi, Kaduna, Kano, Zamfara, Plateau, and Nasawara states) by Global Biofuels Ltd,
- (iv) Sugarcane based biofuel plants at Girei and Demsa Local Government Areas of Adamawa State by Renewable Energy Programme Office, Adamawa State and Green Carbon Afrique with the intent to produce enough sugarcane for local use, export, ethanol, and electricity generation,
- (v) Compost plant at Ikorodu for the treatment of market waste in Lagos State,
- (vi) Waste-To- Energy plant at Ikosi Market in Lagos State, and
- (vii) ENPOST biogas plant at ENPOST farm along Ido-Ijesa road in Ilesa town, Osun State.

FACTORS AFFECTING SOLAR ENERGY UTILISATION

Factors affecting solar energy utilisation in Nigeria are many and varied. One of the major factors is the high initial cost of investment of solar photovoltaic (PV) devices. Since majority of Nigeria's population are poor (NBS, 2012), only very few will afford to buy/install solar PV devices. It has been reported that an estimated 54 per cent of the Nigeria's population live below the poverty line (43 per cent urban, 64 per cent rural), and 90 per cent of the poorest people live in the north (Nigeria Country Programme document, 2014-2017, Unicef). Another contributing factor is the lack of manpower and the desired technological skills. Currently in Nigeria, solar PV devices are only imported and this will increase the cost of investment, added with the absence of equipped laboratories/research centres for solar PV research. Also high illiteracy rate in Nigeria is a serious and important factor. Recently, the Minister of State for Education in Nigeria noted that adult illiterates rose from 25 million in 1997 to 35 million in 2013 (Vanguard, 2013). This makes the focus of most citizens to be on the ease of fetching free fuel wood for their domestic needs without consideration on sustainability of the environment and climate or on the health implications. Low-level of awareness also contribute a significant quota. The level of awareness on the huge health, socio-economic and environmental benefits derivable from solar energy is very low in Nigeria. The current trends of information concerning the development, applications, dissemination and diffusion of solar energy resource and technologies is grossly inadequate and should be stepped up through; the media, mobile networks, schools etc. Lack of effective National Energy Policy is another factor of concern. Although there are many Government policies regarding the adoption of renewable energy, clean energy technology, diversification of energy-mix, and energy efficiency, implementation of such policies is either to slow or deadlocked after appearing in newspaper headlines or news commentaries. Other authors have discussed similar scenarios (Okey 2013., Orji et. al., 2012, Uduma and Arciszewski, 2010., and Bala et. al., 2000). It is also worthy to mention that absence of establishment such as renewable energy data recording stations amongst others impose serious setbacks on the research and applications of renewable energy related products.

FACTORS HINDERING BIOMASS ENERGY UTILISATION

The factors militating on large scale deployment of renewable resources in Nigeria are relatively similar, thus; illiteracy, lack of manpower, lack of awareness, high cost of initial investment, long payback times, and lack of proper Government policies/implementation on renewable resources are all contributing factors. However, lack of infrastructure for bottling biogas for cooking and its use for generation of electricity, and lack of establishment/investment in waste management research and applications by Government is another significant factor. Also rural communities should increase solicitation for assistance from and/or partnership with Non-Governmental Organisations (NGOs) with proven technical and management expertise in new energy sources such as solar, wind, and biomass for easier investment in renewable energy.

EFFECTS OF UNSUSTAINABLE ENERGY USE IN NIGERIA

Unsustainable energy use imposes serious negative consequences on the environment, economy, health, and on the domestic sector amongst others. Improper resource management and lack of commitment by various levels of Government (Federal, State and Local) to invest in energy development are real challenges that hinder successful implantation of any sustainable energy technology in Nigeria. Other research groups have discussed relative concepts (Newsom, (2012), Oyedepo, 2012., Amoo and Fangbale 2013., and Oghogho 2014).

RECOMMENDATIONS

Utilisation of biomass and solar energy are critical and important steps to attaining energy availability, efficiency and sustainability in developing economies lucky to be endowed with such natural and abundant resources like Nigeria. For effective and efficient utilisation of solar and biomass energy in Nigeria, the author strongly recommends that;

- (i) Government should subsidise the cost of importation of solar PV devices,
- (ii) Government should do more to eradicate or reduce poverty to the barest minimum,
- (iii) Government should step up her campaign on reduction of illiteracy in Nigeria. Despite the free education programme and various scholarship schemes introduced by President Goodluck Jonathan, almost all public primary and secondary schools are in a near-total decay in terms of infrastructure, equipments, and very limited manpower,
- (iv) Extensive research in biomass and solar energy should be given special attention by Government,
- (v) Introduction of renewable energy incentives similar to the “feed-in-tariffs” by Government will enhance increased consumption of renewable energy related products,
- (vi) Provision of soft loans by financial institutions, and financial assistance to individuals by Government and non-governmental organisations,
- (vii) Increase in the level of awareness on the merit of investment of/consumption of renewable energy products, and
- (viii) Finally more research centres on renewable energy technology should be established and existing ones to be equipped properly.

CONCLUSIONS

The potentials/utilisation of renewable energy especially biomass and solar energy as a step to energy sustainability in developing economies has been discussed extensively in this work. Utilisation of biomass and solar energy products are considered as viable options to the energy challenges of most developing economies endowed with such natural resources like Nigeria. The study further discussed the existing/on-going biomass and solar PV projects, factors hindering large scale deployment of biomass and solar energy-related products in Nigeria, effects of unsustainable energy use, and finally recommends the way forward. The steps discussed in this study are fundamental to achieving energy sustainability in developing economies blessed with abundant renewable energy resources.

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