International Journal of Science, Environment and Technology, Vol. 3, No 3, 2014, 1043 – 1052
ISSN 2278-3687 (O)

Review Paper

BIOMASS BRIQUETTING AND RURAL DEVELOPMENT IN NIGERIA

***Okey Francis Obi[1] and Busayo Sunday Adeboye[2] and Nneoma Nkem Aneke[1]**
[1]Agricultural and Bioresources Engineering Department, Faculty of Engineering, University of Nigeria, Nsukka, Nigeria
[2]Mechanical Engineering Department, Faculty of Engineering, Osun State College of Technology, Esa Oke, Nigeria
E-mail: profran6@gmail.com (**Corresponding Author*)

Abstract: Biomass is naturally abundant and presents a renewable energy opportunity that could serve as an alternative to fossil fuel; however, it is generally considered a waste in Nigeria. The effective utilization of these materials offers many advantages among which is being a renewable and sustainable energy feedstock for the production of solid fuel - briquettes. One method of achieving this is through briquetting. Briquetting is a relatively new technology in Nigeria as it is in most African countries. Attempts have been made in developing machines for the briquetting of biomass in Nigeria but the numerous failures of these machines including in other developing countries have inhibited their extensive exploitation. This study reviewed some of the factors limiting the commercialization of biomass briquetting in Nigeria particularly as regards to the existing briquetting machines. Ways of commercializing briquette production and its role in the development of rural livelihood were discussed.
Keywords: Biomass, briquetting, appropriate technology, rural development, Nigeria

1.0 Introduction

In recent years, there has been a strong worldwide interest in the development of technologies that exploit renewable energy sources otherwise known as Green Energy, both for environmental and economical reasons. Biomass defined as different materials of biological origin mainly plant material and animal wastes (Sampson et al., 1993; Trebbi, 1993), used primarily as domestic energy source is naturally abundant in rural communities and present a renewable energy opportunity that could serve as an alternative to fossil fuel. Even though increased fossil fuel use has prompted a reduction in biomass consumption for energy purposes over the past 50 years, biomass still provides about 1.25 Billion tons of oil equivalent (Btoe) or about 14% of the world's annual energy consumption (Zeng et al., 2007; Purohit et al., 2006; Werther et al., 2000). Among the various sources of renewable energy, biomass or bio-residues of which agricultural residues form a major component are generally

*Received Apr 28, 2014 * Published June 2, 2014 * www.ijset.net*

considered a waste in poor and developing countries like Nigeria. Tumuluru et al. (2010) reported that wood wastes, agricultural straws, and grasses are the most prominent biomass energy sources and if properly managed, offers many advantages among which is being a renewable and sustainable energy feedstock for briquette production.

It has been reported that biomass provides an average 35% of the energy needs of three-quarters of the world's population which rises to between 60 and 90% in poorest developing countries (Rosillo-Calle, 2007; Lee et al., 2007). Today, biomass energy continues to be the main source of energy in many rural communities in Nigeria albeit in its traditional forms. In these rural communities, it is still a common practice to burn organic waste (biomass) in homes or garbage dumps. Although the direct combustion of charcoal and agricultural wastes is used, this usage of biomass may not be generally considered "suitable" or "efficient" for direct energy applications (Teixeira et al., 2011; Ellegard and Egenéus, 1993). This practice results in the waste of energy, environmental pollution and health problems. The use of biomass as an energy resource is insignificant compared to the volume produced annually in the country. Cioablă and Ionel (2011) projected that by 2030, biomass will be an outstanding solution for individual heating, dominated by wood chips, wood logs and pellets in rural areas. This projection however can only be achieved if conscious effort is made in commercializing the use of biomass as heating energy source. This paper reviews the challenges and opportunities in biomass briquetting in Nigeria and proffers ways for its commercialization.

2.0 Nigeria and its Energy Situation

The energy situation in Nigeria could best be described as deplorable especially in the rural areas. Most rural communities lack access to electricity and the cost of electricity is also unaffordable to the rural people. Energy usage by rural dwellers has been mainly for cooking or heating applications. Njenga et al. (2009) reported that kerosene and charcoal are by far the most commonly used sources of cooking fuel in rural communities. They further added that shortage of low cost sources of energy has resulted in families abandoning traditional foods that require long cooking time, to prepare faster cooking ones. This is a common trend in Nigeria communities both in the rural and urban communities. Some have resulted to using unhealthy materials as energy source such as plastics, with potential negative health impacts. Kerosene has become a scarce commodity in Nigeria and when available is usually very expensive. The Nigerian National Petroleum Corporation (NNPC)/ Capital Oil Initiative on kerosene distribution currently going on in Nigeria aimed at selling kerosene directly to the

people at the official rate of 50 Naira per litre reaches only selected few within the major cities like Abuja, Lagos and Port Harcourt without any consideration for those in the rural areas.

Wood fuel on the other hand is now becoming out of reach due to constant and continuous deforestation, and which would soon be too far away or too scarce to reach (Hood, 2010). Furthermore, the unsustainable harvesting of wood fuel from forest has led to enhanced desert encroachment and has contributed to environmental degradation witnessed in terms of climate change. It is not uncommon for women in rural communities to spend more than 6 hours each day collecting and preparing wood despite the fact that there are often vast quantities of biomass residues and wastes available with the potential to be used as fuel. With the diminishing forest resources and increasing population within and outside the rural communities, there is a pressing need to develop ways of utilizing biomass as a sustainable source of energy. Not only to meet energy demand in an environmentally friendly manner, but also to address pressing human health issues resulting from emission due to incomplete combustion of loose biomass.

3.0 Biomass Densification

Biomass densification represents technologies for converting agricultural residues into solid fuel with or without binders in improving the handling characteristics of the material for transport, storage, and usage. These technologies include briquetting, pelletizing and agglomeration. During densification, loose and smaller biomass is mechanically compressed, increasing its density about ten folds (Tumuluru et al., 2010) as well as its calorific value. Briquetting is a viable and attractive solution in utilizing biomass for fuel applications. There is a real opportunity in rural communities in converting the enormous biomass waste generated from agricultural activities into fuel briquettes. The expansion of densification of biomass depends basically on three factors as identified by Felfli et al. (2011): residue availability, adequate technologies and the market for briquettes. Biomass is readily available and the market for alternative energy sources exist in Nigeria due to the high cost of existing energy sources but the challenge is in developing appropriate technologies that would produce cost effective briquettes that would be competitive in the energy market. It is imperative that more research be focused on the development of appropriate technology for the expansion of this sector as it is an area of pressing need in Nigeria.

3.1 Estimating biomass availability

Agricultural residues have been reported to be a large and an underexploited energy resource, almost always underestimated (Rosillo-Calle, 2007). This is mainly due to the complex nature of biomass production and use, as well as its economics. A number of factors have been identified as constraints in effectively estimating biomass feedstock. According to Oliveira and Franca (2009), predicting the exact amount of residues produced for a specific crop is very difficult due to differences in agricultural practices adopted in different geographical locations even within a particular location, seasonal and cultivar variability, amongst other less relevant factors. Rosillo-Calle (2007) noted that difficulties in estimating resource availability and long-term sustainable productivity are also contributing factors given the large range of conversion technologies, as well as ecological, social, cultural and environmental considerations.

Estimating biomass energy use is also problematic due to the range of biomass energy end-uses and the alternative and competing uses of biomass resources which include animal feed, materials for construction or for natural replenishment of farm lands. The potential of dedicated energy crops or forestry in replacing traditional biomass is considerably uncertain since the traditional sources of biomass they could replace, such as residues from agriculture, forestry and other sources have a much lower and varied energy value. In some situations, data on biomass resource that are site-specific cannot be compared with data from other locations as there are no unified standard unit for quantifying or measuring various forms of biomass resource. All these factors make it very difficult to estimate biomass resource potential for different locations especially on a global scale.

The availability of agricultural residues as energy feedstock is a function of the amount produced, the residue-to-crop ratio, the collection efficiency and the amount used in other competing applications, such as fodder for livestock, feedstock for fertilizer, materials for construction, etc (Purohit et al., 2006). It has been suggested that after accounting for seasonal variation and for the use of agricultural residues for soil conservation and livestock feed, an average of only 15% of the total residue production would be available for energy generation (Bowyer and Stockmann, 2001). The amount of residue produced by a specific crop is usually measured by the Residue Coefficient which is calculated as the residue-to-crop ratio (weight by weight) considering a percent recovery fraction ranging from 15 - 70% depending on the agricultural practices adopted and on the intensity of other competing applications on the location (Lora and Andrade, 2009; Purohit et al., 2006).

3.2 Briquetting press in developing countries

A number of briquetting machines have been developed for use in developing countries. It has been observed that the briquetting technology suitable for developing countries is what Zhanbin (2003) termed normal temperature briquetting technology. It is so termed because briquetting is done at the material original moisture content, usually between 8 – 35% (wet basis), with no requirement for electrical heating as in the case of screw briquetting and no temperature control is required. The system complexity, the area requirement and energy consumption are greatly reduced. The pressure required for the process is also reduced and the cost on drying is saved. It has been observed that in most of the briquetting presses commonly used in rural communities, human strength is required for pressure application resulting in inconsistency in the density of the briquettes and characterized by low productivity. Some researchers (Oladeji, 2011; Uzoma et al., 2011; UNEP, 2009; Bogale, 2009; Njenga et al., 2009; Adekoya, 1998) have developed some manual or low pressure briquette presses based on this technology.

3.3 Limitations of existing briquetting machines

The constraint in the advancement of biomass briquetting in African and in Nigeria particularly has been associated with the development of briquetting press for local commercial manufacture. The existing biomass briquette machines (Oladeji, 2011; Uzoma et al., 2011; Adekoya, 1998) in rural communities in Nigeria address the utilization of biomass for briquette production at household level. As earlier noted, the expansion of the use biomass as an alternative source depends on three factors, two of which are the development of appropriate technology and the market for the briquettes (Felfli et al., 2011). The development of appropriate briquette machines for rural communities should go beyond designs for household use to commercial scale. Some of the commercial limitations associated with existing machines are:

i. The dependence on human strength for direct application of pressure for biomass densification making them gender sensitive and producing poor quality briquettes.

ii. Low production capacities making them unprofitable for commercial use. The low production capacity is mostly associated with the time spent on the ejection of the compressed biomass from the moulds.

iii. Lack of commercial scale-up capabilities hence the machines are limited to household use making the marketing of the briquettes unprofitable.

The numerous failures of these machines have been recorded due to attempts to use them for commercial production of briquettes. Thus, they have been limited in their use due to their inappropriateness for commercial production of briquettes. All of these aforementioned problems need to be addressed before significant progress can be made in biomass briquetting in Nigeria.

4.0 Appropriate Briquetting Technology and Rural Development

A major challenge today in most developing countries is in articulating an effective approach to ensure that benefits from development are within people's reach regardless of where they live. Appropriate technology as a developmental approach, is intended to address such socioeconomic problems, especially in the rural and informal sectors. The technological orientation of this development paradigm has been variously called intermediate, progressive, alternative, light-capital, labour-intensive, indigenous, appropriate, low-cost, community and soft technology. According to Akubue (2000), appropriate technology is defined as an approach to development that not only emphasizes job creation and optimum use of existing skills and resources but also builds on the skills and resources to raise the productive capacity of a community. Dunn (1978) called it a complete systems approach to development that is both self-adaptive and dynamic, because as its users become wealthier and more skilled, they can both afford and also use more expensive technical means. It can therefore be said to be an effective way of gradually adopting modern technology. The focus of appropriate technology in rural areas is tailored to serve the particular needs of a given people or community by securing the best alternative there is for the set of circumstances peculiar to that community.

The growing poverty in most developing countries in part could be attributed to the rapid growth in modern sectors of the economy that is sustained with the most advanced imported technologies (Singer, 1985). Decades of massive importation of advanced technologies and the implementation of large-scale, capital-intensive production methods in developing countries have revealed the shortcomings of such an approach. This is evident in some African countries where advanced briquetting technologies were deployed. First of all, the strategy entails the employment of capital-intensive technology in countries that are short of capital but endowed with surplus labour. Third world countries, by opting for capital-intensive production technology in spite of their shortage of capital, can only afford to create a few jobs for a small number of people due to limited educational and technical capabilities. This implies that several developing countries equip only a very small proportion of their labour force with the means of increasing production. Nigeria, with its low level of

technological development especially in the agricultural sector, has to pay keen attention to the type and nature of technology developed for the rural populace for biomass briquetting. The technological skills of the rural people can be said to be very low hence appropriate technologies that would cater for their level of skill need to be deployed to encourage small scale briquetting enterprises.

A need exists in rural communities of Nigeria for long-term sustainable development in job and wealth creation. Globally, poverty is consistently higher in rural communities as opposed to urban areas. These rural communities are mostly agricultural based and hence agriculture plays a key role in their economic development. However, the role of agriculture as a job and local wealth creator has declined in recent years (Cowan, 2002). Twidell and Weir (2006) noted that the utilization of renewable energy application such as biomass briquetting has been identified to favour rural development and leads to increased cash flow in rural economy. Biomass may offer an opportunity to grow, process, and transport lignocellulosic biomass and rebuild these local agriculture-based economies. The conversion of lignocellulosic biomass to bio-based products promises to have significant impact on rural communities in Nigeria either through job creation or personal savings on expenditure on energy resources. The transition to the use of biomass as energy resource offers commercial opportunity and environmental sustainability, and a more sustainable development practices resulting from more intensive agricultural and forestry utilization (Nelson et al., 2011). Such a transition can create opportunities for new rural bio-based economy, offering solution to indiscriminate burning and disposal of agricultural wastes. As Grassi (1997) in his study revealed that renewable energy sector is labour intensive, and is thus a significant source of employment.

5.0 Conclusion

The need for alternative energy source is staring the Nigerian populace in the face and biomass residues present a readily available solution to the alternative energy need of the people. It is clear that biomass is in abundance in Nigeria especially in the rural communities where agriculture is the main stay of the people. The densification of the biomass using existing briquetting machines may not bring about the needed advancement and commercialization of briquette production due to the limitation associated with their use. Hence, the need to develop appropriate briquetting machines for the commercialization of

biomass briquetting in Nigeria. This is expected to bring about additional cash flow into the rural economy as well as the corresponding employment opportunities it would offer.

References

[1] Adekoya, L.O. (1998). Briquetting of agricultural wastes: A preliminary study. Proceedings of the CIGR Inter-Sections Symposium. National Center for Agricultural Mechanization, Ilorin, Nigeria, pp. 218 – 225.

[2] Akubue, A. (2000). Appropriate technology for socioeconomic development in third world countries. The Journal of Technology Studies XXIV, number 1.

[3] Bogale, W. (2009). Preparation of charcoal using agricultural wastes. Ethiopian Journal of Educ. & Sc., Vol. 5 No 1, pp. 79 – 91.

[4] Bowyer, J.L. and Stockmann, V.E. (2001). Agricultural residues. Forest Products Journal, 51, 10 - 21.

[5] Cioablă, A.E. and Ionel, I. (2011). Biomass waste as a renewable source of biogas production – experiments. In: Alternative Fuel, M. Maximino (Ed.). Published by InTech.

[6] Cowan, T. (2002). Value-added agricultural enterprises in rural development strategies. Washington, DC: Congressional Research Service, The Library of Congress.

[7] Dunn, P.D. (1978). Appropriate technology-Technology with a human face. New York: Schoken Books.

[8] Ellegard, A. and Egenéus, H. (1993). Urban energy: Exposure to biomass fuel pollution in Lusaka. Energy Policy, 21(5): 625 – 622.

[9] Felfli, F.F., Mesa P, J. M., Rocha, J.D., Filippetto, D., Luengo, C.A. and Pippo, W.A. (2011). Biomass briquetting and its perspectives in Brazil. Biomass and Energy (35): 236 – 242.

[10] Grassi, G. (1997). Operational employment in the energy sector. A presentation at the Tagung des SPD – Umweltforums.

[11] Hood, A.H. (2010). Biomass briquetting in Sudan: A feasibility study. The United States Agency for International Development (USAID) and the Women's Refugee Commission.

[12] Lee, S., Speight, J.G. and Loyalka, S.K. (2007). Handbook of alternative fuel technologies. Taylor & Francis Group, LLC.

[13] Lora, E.S. and Andrade, R.V. (2009). Biomass as energy source in Brazil. Renewable and Sustainable Energy Reviews, (13): 777 - 788.

[14] Nelson, P., Hood, E.E. and Powell, R. (2011). The Bio-economy: A new era of products derived from renewable plant-based feedstocks. In: Plant Biomass Conversion, First Edition, E.E. Hood, P. Nelson and R. Powell (Eds.). John Wiley & Sons Inc.

[15] Njenga, M, Karanja, N., Prain, G., Malii, J., Munyao, P., Gathuru, K., and Mwasi, B. (2009).Community-based energy briquette production from urban organic waste at Kahawa Soweto informal settlement, Nairobi.Urban Harvest, Peru.Working paper series, Paper 5.

[16] Oladeji, J.T. (2011). Comparative fuel characterization of briquettes produced from two species of corncob. Researcher, 3(4).

[17] Oliveira, L.S. and Franca, A.S. (2009). From solid bio-wastes to liquid biofuels. In: agricultural wastes: Agriculture Issues and Policies Series. G. S. Ashworth and P. Azevedo (Eds.).Nova science publishers, Inc.

[18] Purohit, P., Tripathi, A.K. and Kandpal, T.C. (2006). Energetics of coal substitution by briquettes of agricultural residues. Energy (31): 1321 – 1331.

[19] Rosillo-Calle, F. (2007). Overview of bioenergy. In: The Biomass Assessment Handbook: Bioenergy for a Sustainable Environment. F. Rosillo-Calle, P. de Groot, S.L. Hemstock and J. Woods, (Eds.). Published by Earthscan, UK.

[20] Sampson, R.N., Wright, L.L., Winjum, J.K., Kinsman, J.D., Benneman, J., Kursten, E., Scurlock, J.M.O. (1993). Biomass management and energy. Water, Air, and Soil Pollution, 70 (1–4), pp. 139–159.

[21] Singer, H. (1985). Appropriate technology and basic-needs strategy. In M. Carr (Ed.), The AT reader: Theory and practice in appropriate technology (pp. 27-28). Croton-on-Hudson, NY: Intermediate Technology Development Group of North America.

[22] Stanley, R. (2003). Fuel Briquette making. Legacy Foundation.

[23] Teixeira, S.R., de Souza, A.E., Peña, A.F.V., de Lima, R.G. and Miguel, A.G. (2011). Use of charcoal and partially pyrolysed biomaterial in fly ash to produce briquettes: Sugarcane bagasse. In: Alternative Fuel, M. Maximino (Ed.). Published by InTech.

[24] Trebbi, G. (1993). Power production options from biomass: The vision of a southern Euorpean utility. Bioresoure Technol., 46: 23 – 29.

[25] Tumuluru, J.S., Wright, C.T., Kenny, K.L., and Hess, J.R. (2010). A review of biomass densification technologies for energy application. A report prepared for the U. S. Department of Energy by the Idaho National Laboratory, Biofuels and Renewable Energy Technologies Department, US.

[26] Twidell, J.W. and Weir, A.D. (2006). Renewable energy resources. Second Edition. Taylor and Francis Group, London and New York.

[27] UNEP (2009). Converting waste agricultural biomass into a resource - Compendium of technologies. United Nations Environmental Programme, Division of Technology, Industry and Economics, International Environmental Technology Centre Osaka/Shiga, Japan.

[28] Uzoma, C.C., Okafor, I. F. and Okpara, C.G. (2011). Fuel briquettes technology can save Nigeria's trees. Continental J. Environmental Sciences 5 (1): 20 – 28.

[29] Werther, J., Saenger, M., Hartge, E.U., Ogada, T. and Siagi, Z. (2000). Combustion of agricultural residues. Progress in Engineering and Combustion Science, (26): 1 – 27.

[30] Zeng, X.Y., Ma, Y.T. and Ma, L.R. (2007). Utilization of straw in biomass energy in China. Renewable and Sustainable Energy Revisions, (11): 976 – 987.

[31] Zhanbin, C. (2003). Normal temperature briquetting technology for biomass with original moisture content. International Conference on Bioenergy Utilization and Environment Protection, 6th LAMNET Project Workshop Proceeding, Dalian, China.