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Towards Sustainable Charcoal Production and its Use for Energy Generation in Nigeria

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Charcoal plays a significant role in the energy requirements of many developing countries. This is especially the case in Nigeria, where dependence is increasing due to growing urban populations, and limited accessibility to alternative modern fuels. Charcoal production is rural areas form of off farm secondary occupation, although this provides income for poor rural dwellers. At present, charcoal and firewood constitute the main source of fuel for cooking by over 76% of the Nigerian population. The major reasons of sustainable charcoal production are not fully understood, based on this, the paper recommends ways of improving efficient and sustainable production of charcoal in Nigeria.

Keywords Sustainable, Charcoal, firewood, fuel wood, Pyrolysis.

INTRODUCTION

Charcoal production is an important economic activity in most rural areas of developing countries, and an important source of energy in developing countries. According to Tee et al (2009), energy demand in Nigeria has increased significantly in recent times as a result of population increase and urbanization, adding that, the increased demand is, however, more pronounced in the consumption of wood fuel, particularly charcoal.

Fuel wood consumption in Africa is estimated to be 544.8 million m^3 of firewood and 46.1 million tons of charcoal by 2030 (Arnold and Persson, 2003). Countries with high per capita fuel wood (charcoal) demand, indicate the importance of wood energy in the socioeconomic development of the country (FAO, 2001; Yevich and Logan, 2003). In 1992, 24 million tones of charcoal were consumed worldwide ((Aweto, A.O, 1995). Developing countries account for nearly all of this consumption, and Africa alone consumes about half of the world's production.

Charcoal production has increased by about a third from 1981 to 1999, and is expected to increase with the rapidly growing population in the developing world (Waddams, 2000). Despite the cooking advantages of charcoal and charcoal's ranking on the cooking ladder, this preliminary review suggests that charcoal may be far better than the less preferable biomass fuels, biomass residues and fire-wood. Contrary to popular assumptions that charcoal is an old technology and thus will phase out on its own, this study indicates that charcoal is a good energy source and likely to be used as long as the feedstock supply and the demand from impoverished people in the developing world exist.

Globally, there is a marked trend for developed countries to have a high per capita usage of energy as a whole, of which wood is a minor component compared with developing countries with a low per capita energy input but a high proportion consisting of fuel-wood (Derkyi, 2011). Global fuel-wood consumption is dominated by Asia and Africa (> 75% of total volume) with South America ranking third at 10% (Derkyi, 2011). Five countries: China, India, Indonesia, Nigeria and Brazil, account for about half the charcoal and firewood produced and consumed each year (Ogundele et al., 2012).

The heightened and growing demand for charcoal in Nigerian urban centers, consequent upon the proposed withdrawal of petroleum subsidy by government and burgeoning urban population, fueled by rural-urban migration, raises the need to examine the economics of charcoal production in energy generation.

METHOD

This study relied solely on secondary information available from different sources; published reports, documents of research and development of academic institutions (Journals) and individual researchers. There was no collection of primary data for the purpose of this study.

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Raw Material

Both hardwood and softwood can be used as a raw material. Also, sawdust, wood shavings, fruit stones, nuts, nutshells, corn cobs, bark, cotton seeds, and similar products can be used. In these cases the resulting charcoal needs to be briquetted. Lump wood is used directly from the forest or from wood processing industries (Arnold et al., 2005).

Charcoal Production

Charcoal is the solid residue remaining when wood is carbonized under controlled conditions in a closed space (Feinstein et al., 1991). Control is exercised over the entry of air during the carbonization process so that the wood does not burn away to ashes, as in a conventional fire, but decomposes chemically to form charcoal. The pyrolysis process, once started, continues by itself and gives off considerable heat. However, this pyrolysis, or thermal decomposition of the cellulose and lignin of which the wood is composed, does not start until the wood is raised to a temperature of about 300° Celsius (Feinstein et al., 1991).

In traditional methods of production, some of the wood loaded into the kiln is burned to dry the wood and raise the temperature of the whole of the wood charge, so that pyrolysis starts and continues to completion by itself. The wood burned in this way is lost. All carbonizing systems give higher efficiency when fed with dry wood, since removal of water from wood needs large inputs of heat energy. The pyrolysis process produces charcoal which consists mainly of carbon, together with a small amount of tarry residues, the ash contained in the original wood, combustible gases, a number of chemicals mainly acetic acid and methanol and a large amount of water which is given off as vapour from the drying and pyrolytic decomposition of the wood (Arnold et al., 2005). When pyrolysis is completed the charcoal, having arrived at a temperature of about 500° Celsius, is allowed to cool down without access of air; it is then safe to unload and is ready for use (Bulaghsingala, 1983 and Arnold et al., 2005).

Energy Loss During Conversion

The average conversion ratio of 5:1 means that 5 kg of air-dried fuelwood is burnt to produce one kg of charcoal. Five kg of air-dried wood is equivalent to 75 MJ (assuming an energy content of 15 MJ/kg), so when this produces 1 kg or 28 MJ in the form of charcoal, there will be a net energy loss of 47 MJ (or about 62%). Part of the energy loss during the charcoal making process is compensated during end use, because charcoal stoves have higher efficiencies than fuelwood stoves (average efficiency of 30% for charcoal stoves against only 10-15% of untended open fire or tripod). (**Tara N. Bhattarai;** Wood Energy Resources Specialist, RWEDP and SEI, 2002)

User Convenience for Energy Generation

Charcoal can be an excellent domestic fuel. Charcoal is cleaner, easier and less smoky and smelly than other biomass fuels. Charcoal has a higher energy density than other biomass fuels and can be stored without fear of insect problems (Madon, 2000). It has excellent cooking properties: it burns evenly, for a long time, and can be easily extinguished and reheated. It can be used in smaller quantities with cheap burning devices for domestic application, the study also clearly showed charcoal used in energy-efficient stoves to be the cheapest fuel per unit of energy (Foster, 2000 and Adelekan et al., 2006). It is therefore often used prior to the adoption of other more expensive modern fuels. Urban women interviewed during household energy surveys in Ethiopia, Chad, Madagascar, Mali, Nigeria, the Niger, and Senegal did not like to cook with wood because they found it difficult to kindle, awkward, dangerous for children, smoky and messy (Madon, 2000). Charcoal is perceived to lack most of these negative effects, and it is priced more competitively than LPG and kerosene, which are still too expensive for many people (Foster, 2000 and Arnold et al., 2005). Except in some countries, industrial application of charcoal in Africa is limited. But a large number of traditional rural industries and commercial establishments use it as an energy source.

Energy Content and the Economics of Its Used

The calorific value of charcoal primarily depends on its quality, depending on the amount of water, volatiles and ash content. Its gross heating value is estimated to be within the range of 28 - 30 MJ/kg (Shinogi et al., 2003). Freshly made charcoal has zero water content, but it may rapidly gain moisture from the air during storage. Charcoal commonly used for domestic purposes may have a net calorific value of 28 MJ/kg (Foley, 1986). That means, its net energy value is roughly twice as much as for air-dried fuelwood. This big difference makes charcoal cheaper to transport over a longer distance compared to fuelwood. It is true that by converting fuelwood into charcoal one could benefit from reducing the transportation cost per MJ. On the other hand, by converting wood into charcoal one also looses a substantial amount of energy (Foley, 1986). If the recovery (or yield) of charcoal is 20% of the initial weight of the air-dried wood, the conversion ratio is 5:1 depending upon the method used (Foley, 1986). The traditional practice of charcoal making in open pits may yield a lower amount of charcoal compared to improved charcoal kilns.

Factors to Consider For Promoting Charcoal Use

In some areas, charcoal is not yet being used as a domestic fuel, and the purchasing power of people may be too low to allow for buying traded fuel. People often look for free supply sources to meet their domestic cooking fuel need. In such areas the prospect for charcoal production and trade will be non-existing and should not be promoted. In other areas a long tradition of charcoal use for domestic fuel exists, and local industrial and commercial activities need charcoal. There, people are aware of the importance of charcoal and its commercial development can be promoted. With a high demand for high quality charcoal, these areas deserve special considerations for promoting commercial charcoal production and trade, with additional investment and application of improved technologies.

In areas where the demand for better quality charcoal (with a higher carbon content) is high for industrial uses, the need for technological innovation in charcoal making will be paramount and should be promoted. Similarly, many urban centers and towns demand charcoal for domestic fuel or for industrial and commercial applications (e.g. cooking and food processing). In such areas there is a need for improvement of traditional charcoal production technology, not only for higher recovery in production but also for quality enhancement.

Factors Affecting Production Potential

Factors that could affect commercial charcoal production and trade include: scarcity of wood for charcoal making; ambiguity, inadequacy or flaws in government regulations (e.g. Existing regulations often look restrictive rather than supportive in the name of forest conservation); lack of understanding of local wood fuel systems, which often tend to adapt themselves to changing situations; informal nature of operations and the market; variations in the systems to match specific site conditions (simple or complex and sophisticated). Individual actors play specific roles only and will not be in a position to influence the system independently.

Supply Sustainability and Quality

Maintenance of the supply and quality of charcoal in the market is a difficult task. It cannot be regulated by urban traders or consumers, since a large number of charcoal operations are currently unregistered, and are often illegal, relying on illegally collected wood from public forests. The whole operation may take place within the boundary of government managed forests which is illegal according to most existing forestry legislations. This is often viewed as a challenge to forestry agencies.

POLICY RECOMMENDATIONS

1. A need exists for official recognition of charcoal production and marketing by national energy policies.
2. Energy policies in many countries in Africa tend to put more emphasis on commercial energy, denying biomass energy the comprehensive treatment it deserves.
3. A regulatory framework should be put in place. Such a framework should:
 a) Outline standards and guidelines for the production of sustainable charcoal, as well as simple licensing procedures.
 b) Recognize charcoal associations by creating awareness and make the public more knowledgeable on charcoal trade.
 c) Encourage pilot projects to demonstrate that sustainable charcoal production can be practiced.

Cost Recovery and Scale of Operation

The economic cost of charcoal production may vary significantly depending on the type of production systems. In a traditional system the producer collects the wood free of cost, and uses his labor to dig the pit to convert the wood into charcoal, and transports the final products to the market for sale. There is no cash investment in this type of operation. The production cost is virtually zero in such cases (except for tools that are purchased for common household use which are also used for wood cutting and pit digging), unless one has to pay a nominal fee to the forestry department as a government royalty for wood and to obtain a permit for making charcoal in the forest. Then this cost is the only cash investment in charcoal making, which rarely is the case.

The producer of charcoal under such a system simply works to convert free time into a marketable product, in the absence of other cash earning opportunities. As long as the market price of charcoal is attractive enough to encourage this type of production, the poor will see it as an attractive option to earn cash. The commercial producer, on the other hand, has to consider whether he can recover the cost of inputs to the manufacturing process from the returns when the charcoal is sold in the market. This makes the investment more risky and the risk increases as the scale of operation expands. This type of producers will try to maximize the returns from their investment by introducing innovations, both technological as well as managerial.

CONCLUSION

Charcoal production remains a very small sub-sector of the forest industry in Nigeria, contributing significantly in term of energy for the household. Nevertheless, from the limited statistics available, charcoal production does appear to have local socioeconomic significance, especially in rural areas where alternative livelihoods are limited. For Nigeria to be among the top 20^{th} economy, it requires urgent action to increase energy access and supply, improve energy efficiency and enhance energy management and institutions. The Nigeria's Vision 2030 proposes development projects that will increase the demand on energy supply. The country must therefore generate more energy at a lower cost and increase efficiency in energy consumption. There are several different industrial and commercial-use products that are manufactured using charcoal apart from heat generation. Products from charcoal can be soon a part of communications and systems of transportation, computer networks, and even space expeditions.

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