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Assessment of Availability and Cost of Energetically Usable Crop Residues in Nigeria

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Introduction

Nigeria is the most populous country in Africa with a 2006 population estimate of about 140 million people (NPC, 2007). The country experiences one of the largest population growth rates in the world. According to Aboyade (2003), Nigeria's population had more than tripled from 33 million in 1950 to 112 million in 1995 and is projected at present growth rate to reach figure of 339 million by 2050. The land area of about 910,000sq km makes Nigeria to be the 13th largest country in Africa with a population density higher than the average. Nigeria is rich in both fossil fuels such as crude oil, natural gas, coal, and renewable energy resources like solar, wind, biomass, biogas, etc. The total energy consumption in Nigeria using 2005 data is 26.65 ×10^6 toe.

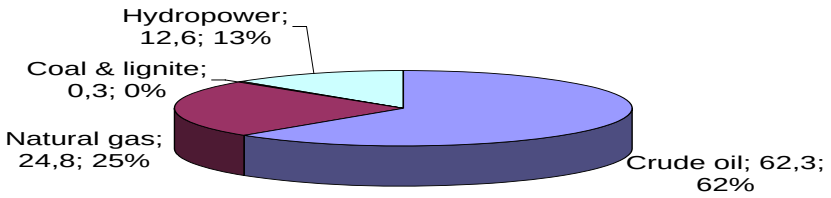

Fig. 1 Total Primary Energy Consumption = 26.65 x 10^6 toe

Agricultural and Energy Situations in Nigeria

Nigeria has a land area of 98.3 million hectares. At present about 34 million hectares or 35% are under cultivation. There is no doubt that considering the vast area of uncultivated land coupled with the natural fertility of its soil, Nigeria has great agricultural potentials. In Nigeria, agriculture has remained the largest sector of the economy. It generates employment for about 70% of Nigeria's population and contributes about 40% to the Gross Domestic Product (GDP) with crops accounting for 80%, livestock 13%, forestry 3% and fishery 4%. It plays significant roles in the nation's economic development.

Nigeria is rich in both fossil fuels such as crude oil, natural gas, coal, and renewable energy resources like solar, wind, biomass, biogas, etc. According to Akinbami (2001), the national energy use trend reveals a dichotomy between the urban and the rural households. This development is explained by the two forms of energy being consumed in the country, namely commercial energy (petroleum products, natural gas, coal, and electricity), and non-commercial or traditional energy (mostly fuel wood and other biomass).

Methods

The following calculation methods were adopted in the estimation of amount and energetic values of energetically available crop residues in Nigeria:

1. For known quantities of crop production, it is possible to estimate the amounts of agricultural residues produced using the residue to product ratio (RPR).
2. The amount of residue used for purposes other than energy was estimated using facts obtained from the literature and other secondary sources.
3. The time variation of the total crop produced was expressed in a simple regression model to develop functional relationship between crop production and total availability of agricultural residue for different selected crops.
4. The energy values of the available crop residues were computed by multiplying the known heating values (MJ/kg) of the residues by their estimated weight (kg).
5. In making the estimation of the total cost of residues, a simple procedure was followed as follows:

Harvesting Cost

Assuming that the harvesting of the residue is done manually, the harvesting cost of residues, C_{rh} is estimated by dividing the daily wage rate of unskilled labour, W (in US $ per day), by the harvesting capacity, hc (in tonnes per day) of the labour per day. Thus,

$$C_{rh} = W / h_c \quad (1)$$

Collection Cost

The collection cost, C_{rc}, can be estimated by dividing the daily wage rate, W, by the carrying capacity, C_c (tonnes per trip) and the number of trips, n, made by a person in a day. Thus,

$$C_{rc} = W / (C_c \times n) \quad (2)$$

Transportation Cost

The transportation cost can be expressed as:

$$C_{rt} = d\left(F_c \times C_f + W_d\right) / (t_c \times t_s) \quad (3)$$

Where F_c is fuel consumption of the tractor per hour of operation, C_f the cost of fuel, Wd the driver's wage per hour, d the distance of transportation, t_c the carrying capacity of the tractor and ts the transportation speed in km/h.

Total Cost

The total cost of agricultural residues, C_r is the addition of eqs 3 to 6, which is

$$C_r = C_{rh} + C_{rc} + C_{rt} \quad (4)$$

Results and Discussion

In this investigation, 17 residues from 9 major crops in Nigeria were used. The selected crops are maize, cassava, millet, plantain, groundnuts, sorghum, oil palm, palm kernel and cowpeas Cassava production increased from 32 million tonnes in 2000 to 38.2 million tonnes in 2004, an increase of about 20 %. All other selected crops also experienced increases in their production outputs from 2000 to 2004. These are maize (16 %), millet (3 %), plantains (23 %), groundnuts (1.2 %), sorghum (4 %), oil palm (2 %), palm kernel (6 %) and cowpea (8 %)..The increases observed in the outputs of these crops are an indication of increasing quantity of residues that could be derived from them. Table 1 presents the estimated quantity of agricultural residues generated in Nigeria using 2004 production data. Only four of the residues (maize cob, stalks and husk, and millet stalks) require harvesting cost of $ 16.67/tonne. All other residues are always harvested with the major products and therefore do not require separate harvesting costs.

The estimated costs of the selected residues (varying between $ 6.45/tonne and $ 23.12/tonne) are much lower than the published costs for most conventional biomass resources such as coal in Nigeria. Thus, the selected residues are economical feedstock in biomass combustion and gasification**.**

Conclusions

1. The estimated energy value of the energetically available residue using 2004 production data is 878 PJ or 20.81 million toe of fuel-oil, which equals about 82% of the present Nigeria's annual energy consumption.

2. The cost estimates for the production of these wastes using 2004 crops production data vary from $ 13.79/tonne to $ 65.94/tonne, depending on the farm residue and the transportation distance.

Table 1. Estimation of Availability and Costs of Energetically Usable Crop Residues in Nigeria.

Residue	Heating Value (MJ/kg)	Total Amount (10^6 t)	Energetically available amount of residue			Cost of Residue	
			Share (%)	Weight* (10^6 t)	Energy (10^6 toe)	(US $/tonne)	(US $/$10^6$toe)
Maize cob	16.63	1.30	100	1.30	0.51	23.12	9.07
Maize stalk	15.51	9.56	100	9.56	3.51	23.12	9.07
Maize husk	15.56	0.96	100	0.96	0.35	23.12	9.07
Cassava stalk	13.38	2.37	20	0.47	0.15	6.45	2.06
Cassava peelings	10.61	9.54	30	2.86	0.72	6.45	2.06
Millet stalks	15.51	11.00	30	3.30	1.21	23.12	9.07
Plantains peelings	12.56	8.44	100	8.44	2.51	6.45	2.06
Plantains trunks/leaves	15.48	1.05	100	1.05	0.39	6.45	2.06
Groundnuts husks/shells	15.56	1.40	100	1.40	0.52	6.45	2.06
Groundnuts straw	14.40	6.76	100	6.76	2.30	6.45	2.06
Sorghum straw	14.40	14.05	100	14.05	4.79	6.45	2.06
Oil palm shells	21.10	0.31	100	0.31	0.16	6.45	2.06
Oil palm fibre	19.94	0.67	100	0.67	0.32	6.45	2.06
Oil palm empty bunches	19.41	1.10	100	1.10	0.51	6.45	2.06
Palm kernel shells	21.10	3.92	50	1.96	0.99	6.45	2.06
Palm kernel cake	10.61	2.18	0	0	0	6.45	2.06
Cowpeas shells	19.44	4.05	100	4.05	1.87	6.45	2.06

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