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Assessment of Energy Consumption Pattern of Local Palm Oil Production in ITU and Abak Local Government Area of Akwa Ibom State, Nigeria

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ABSTRACT : This study investigates the energy consumption pattern of selected commercial palm oil mills in Itu and Abak local government areas of Akwa-IbomState. The energy consumption pattern and predictive model equation for source energy used in local palm oil production was determined. Ten defined unit operations were established for the production of local palm oil; bunch reception, slicing, threshing, sieving, boiling, digestion, pressing, fibre and nut separation, repressing, clarification and purification. Manual, wood fuel, palm residue, and liquid fuel were the main source of energy input used in the palm oil processing mill. The average unit operation energy source for boiling (2007MJ) was the highest, accounting for 74.5% of the total energy consumption. This was followed by clarification and purification (437.7MJ, 16.2%), fibre and nut separation (126.3MJ, 4.69%), digestion (105.8MJ, 3.93%), threshing (5.454MJ, 0.2%), bunch reception (4.791MJ, 0.18%), pressing (2.345MJ, 0.09%), bunch slicing (2.16MJ, 0.08%), repressing (1.652MJ, 0.06%), sieving (1.125MJ, 0.04%). The studies shows that energy consumption pattern from location to location vary due to method of processes, time, and number of person engage in a unit and the type of fuel being used.

KEYWORDS: Assessment, Consumption, Energy, Palm Oil, Production.

I. INTRODUCTION

Palm oil is the world's largest source of edible oil, accounting for 38.5 million tonnes or 25% of the global edible oil and fat production (MPOC, 2007). Palm oil is a product extracted from the fleshy mesocarp of the palm fruit (Elaeisguineensis). The global demand for palm oil is growing thus, the crop cultivation serves as a means of livelihood for many rural families, and indeed it is in the farming culture of millions of people in the country. Hence, oil palm is often referred to as a crop of multiple values, which underscores its economic importance [2]. The demand for domestic and industrial application of palm oil has continued to increase [4]. It is estimated that for every Nigerian household of five, about two liters of palm oil are consumed weekly for cooking [1]. However, palm oil is an essential multipurpose raw material for both food and non-food industries [3]. Palm oil is used in the manufacturing of margarine, soap candle, base for lipstick, waxes and polish bases in a condense form, confectionary [5], [1], [3].

Apart from the feed stocks price, the efficiency of the production process is the other important factor that strongly affects the cost of crude palm oil produced. Therefore, the improved overall production efficiency can lower the production cost to be more competitive to the world and increase the business profitability. Efficiency improvement of process units and waste minimization are examples of the means to improve overall efficiency. Utilizing wastes generated from the oil production process not only replaces the use of more costly and price vulnerable fossil fuels, but also reduce the impact to global warming. Energy consumption patterns in the world today shows that Nigeria and indeed African countries have the lowest rates of consumption.

Nevertheless, Nigeria suffers from an inadequate supply of usable energy due to the rapidly increasing demand, which is typical of a

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developing economy. Paradoxically, the country is potentially endowed with sustainable energy resources. Nigeria is rich in conventional energy resources, which include oil, natural gas, lignite, and coal. It is also well endowed with renewable energy sources such as wood, solar, hydropower, and wind [10].

Thus in the quest for optimal development and efficient management of available energy resources, equitable allocation and efficient utilization can put the economy on the part of sustainable growth and development. Arising from this argument, adequate supply of energy thus becomes central to the radical transformation of the nation's economy [11].

This study is to investigate the energy consumption pattern of selected commercial palm oil mills in Itu and Abak local government areas of Akwa Ibom State by studying the amount of energy consumed at each stage of palm oil production.

II. MATERIALS AND METHOD

Materials

Data collected from four palm oil processing mills in Itu and Abak local government area of Akwa-Ibom State were used for the quantification of energy in each unit operation. The methodology used included on-site study of all unit operations in the mills, the use of structured questionnaire and oral interview of supervisors and their workers. Inventory of number of person involved (N), time required for production (h), liquid fuel (L), quantity of palm kernel shell fuel (PKS) (kg), quantity of wood fuel (kg) and quantity of oil palm frond fuel (kg) used and material flow for ten defined unit operations was made. The parameters required for energy evaluation for each unit operation are presented as seen in Table 1.

Method

The main energy resources utilized in the mills were identified as manual (human labour), liquid fuel energy (fossil fuel), wood fuel energy (wood fuel), palm kernel shell fuel (by-product of palm fruit) and oil palm frond. Ten unit operations defined for the palm oil production were bunch reception, bunch slicing, threshing, sieving, boiling, digestion, pressing, nut and fibre separation, repressing and clarification/purification.

The weight of sample input was measured using a weighing balance. For each of the operations, the number of persons involved was counted and the time taken was also recorded using a stopwatch with all intermittent resting and idle period deducted. Before commencement of digestion/separation operation, known quantity of fuel was measured into digester/fibre and nut separation machine. After the completion of the batch, the quantity of fuel left in the tank was measured and recorded. The difference in these readings represented the quantity of fuel used. The weight of fuel wood used was determined by similar difference. From this procedure, it was possible to assign, wood fuel energy, manual energy and liquid fuel energy, and a combination of two or all the forms of energies as the case may be, to each unit operation [8].

The energy analysis was based on process analysis in which the direct energy consumption in every successive production step was estimated and the materials input to each operation also indicated. These data collected was converted to energy equivalent using developed energy equations (1), and (2). Where (1) is manual energy estimation formula, (2) is the energy relationship that presents the heating value of fuel.

(1)

Manual energy estimation can be computed based on the value recommended by [12]

Where

Em stands for manual energy estimation,

3.6 = conversion factor (1kwh = 3.6 MJ)

0.075 = the average power of a normal human labour in kW; number of person involved in the operation; and

Ta = useful time to accomplish a given task (operation) in hour.

The energy demand (E) for operations utilizing fuel to run internal combustion engine is directly proportional to the quantity of fuel used (W),

$E \alpha W$, [12] given in equation 2.

Energy from fossil fuel (diesel and petrol) was assigned to each unit operation according to their level of consumption. The total quantity of energy consumed from fossil fuel was estimated by multiplying the quantity of fuel consumed by its lower heating value.

[12]

(2)

Where is the constant of proportionality which represents the calorific value of fuel.

The processing facilities for the mills in case one and two were similar. All the mills selected were evaluated over the same period and season, and as a result the error of seasonal variation changes was eliminated. No prior experimental conditions were used since data collection in each locality was carried out when the mills were in operation.

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Table 1: Parameters Required for Energy Evaluation for Each Unit Operation

S/N	Operation	Required Parameter
1	Bunch reception	Time taken (h)
		No. of person involved
2	Bunch slicing	Time taken (h)
		No. of person involved in slicing
3	Threshing	Time taken (h)
		No. of person involved in threshing
4	Sieving	Time taken (h)
		No. of person involved in sieving
5	Boiling	Time taken (h)
		No. of person involved in boiling
		Quantity of PKS used (W)
		Quantity of palm frond used (W) Quantity of wood fuel used (W)
		Calorific value of PKS (MJ/kg)
		Calorific value of palm frond (MJ/kg) Calorific value of wood (MJ/kg)
6	Digestion	Time taken (h)
		No. of person involved in digestion
		Quantity of diesel used (l)
		Calorific value of diesel (MJ/kg)
7	Pressing	Time taken (h)
		No. of person involved in pressing
8	Nut and fibre separation	Time taken (h)
		No. of person involved in separation
		Quantity of diesel used (l)
		Calorific value of diesel (MJ/kg)
9	Repressing	Time taken (h)
		No. of person involved in repressing
10	Clarification and purification	Time taken (h)
		No. of person involved
		Quantity wood fuel (MJ/kg)
		Calorific value of wood fuel (l)

III. RESULTS AND DISCUSSION

The energy used per unit operation in location 1 and 2 for Palm oil production from 1000kg of Palm fruit are presented in Tables 2 and 3. Figure 1 and 2 shows the energy source comparison and consumption level in the respective locations. The observed and predicted result of the total energy in each case involved and the model equations of the energy requirements in relation to source of energy is presented in Table 4. The Equation has the coefficient of determination as 1.

The result of analysis of variation (ANOVA) at 5% significant difference was conducted for the 4 cases for the energy requirement and the different unit operations for the production of as presented in Table 5.

Table 2.Time and Energy Requirement for Production of Palm Oil for Location 1(Ikot)

S/N	Process	Time (h)	Manual energy (MJ)	Liquid fuel (MJ)	Wood fuel (MJ)	Palm kernel shell (MJ)	Oil Palm Frond (MJ)	Total energy (MJ)	Percentage energy (MJ)
1	Bunch reception	**6.137**	4.97					4.971	0.18
2	Bunch slicing	4	2.16					2.16	0.08

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3	Threshing	6.733	5.45					5.454	0.2
4	Sieving	2.083	1.13					1.125	0.04
5	Boiling	1.86	1			1798	207	2007	74.5
6	Digestion	1.16	0.63	105				105.8	3.93
7	Pressing	2.18	2.35					2.354	0.09
8	Fibre and nut separation	1.467	1.19	125				126.3	4.69
9	repressing	1.53	1.65					1.652	0.06
10	Clarification and Purification	1	0.27			437.4		437.7	16.2
	Total	**28.15**	**20.8**	**230**	**-**	**2236**	**207**	**2694**	**100**
	Total %		**0.77**	**8.55**	**-**	**83**	**7.68**	**100**	

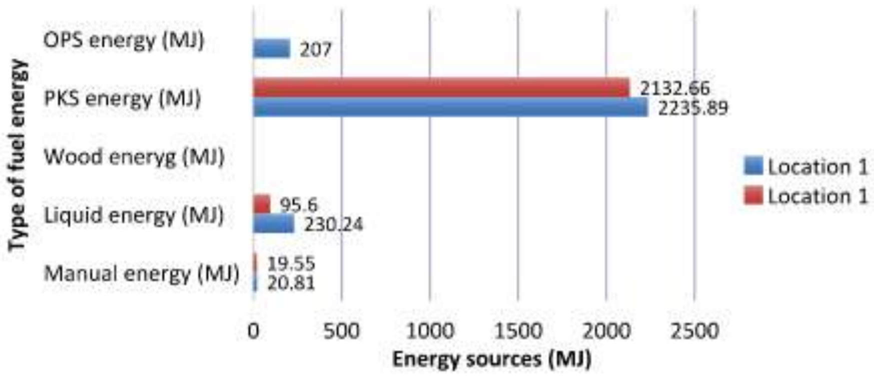

Figure 1: Energy Source Comparison and Consumption Level in Location One

Table 3.Time and energy Requirement for Production of Palm Oil for Location2 (Abak)

S/N	Process	Time (h)	Manual energy (MJ)	Liquid fuel (MJ)	Wood fuel (MJ)	Palm kernel shell (MJ)	Oil Palm Frond (MJ)	Total energy (MJ)	Percentage energy (MJ)
1	Bunch reception	4.67	5.04					5.04	0.22
2	Bunch slicing	7.2	1.94					1.94	0.09
3	Threshing	5.1	5.51					5.51	0.25
4	Sieving	1.5	1.62					1.62	0.07
5	Boiling	2.87	1.55			1645		1646	73.2
6	Digestion	1.27	1.03	95.6				96.63	4.3
7	Pressing	2	0.54					0.54	0.02
8	Fibre and nut separation	2.27	1.84					1.84	0.08

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9	repressing	1.08	0.29					0.29	0.01
10	Clarification and Purification	0.73	0.2			487.9		488.1	21.7
	Total	**28.68**	**19.6**	**95.6**		**2133**		**2248**	**100**
	Total %		**0.87**	**4.25**		**94.88**		**100**	

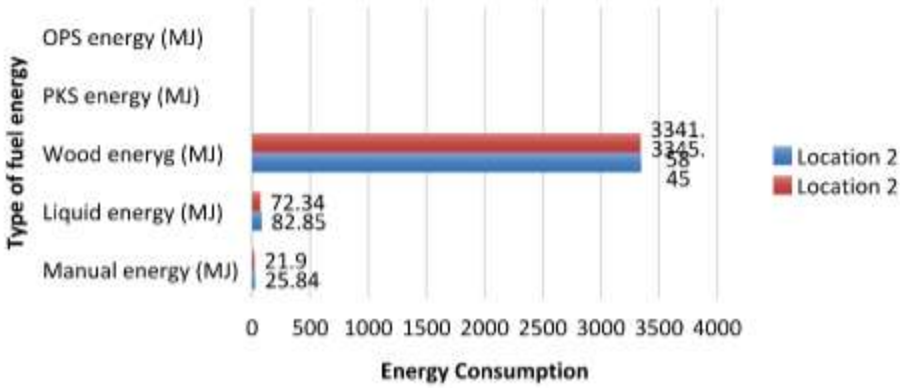

Figure 2: Energy Source Comparison and Consumption Level in Location Two

Table 4: Predictive Regression Model Equation for Energy Requirement in the Production of Local Palm Oil

Source Energy Model Equations	
	1

Table 5: ANOVA Palm OIL Production of Cases Studied

Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	16.79776	1	16.79776	0.566482	0.470887	5.117355
Columns	12714394	9	1412710	47641.72	5.89E-20	3.178893
Error	266.8752	9	29.6528			
Total	12714678	19				

IV. DISCUSSION

Energy Use Analysis

From the Table 2 and 3 and Figure 1 and 2, it was observed that in the two mills, thermal energy from palm kernel shell is mostly used, followed by energy from liquid fuel. This shows that there is a measure of mechanization in the production of palm kernel oil in the two plants. About 83% of the total energy in location 1 was due to thermal energy from palm kernel shell which increased to 94.9% of total energy in location 2 all in Akwa-Ibom State, Nigeria.

Development of Energy Predictive Regression Model

The observed and predicted result of the total energy in each case involved and the model equations of the energy requirements in relation to source of energy as presented in Table 4, Shows that the equation has the coefficient of determination as 1. This is a perfect fit. It is expected that the equation will give the same result of energy requirement(s) if all conditions are met.

The regression equation was generated from the experimental results of 4 cases using IBM SPSS Statistics, Version 20. The general multivariate linear models showing total energy in MJ (.) with independent variables: manual fuel (), liquid fuel (L), wood fuel (), palm residue (), was used to develop the model.

Test of Significant Difference of Cases and Energy of Unit Operations

The result of analysis of variation (ANOVA) at 5% significant difference was conducted for the 4 cases for the energy requirement and the different unit operations for the production as presented in Table 5.There was significant difference in the energy requirements for all the 4 cases at 95% confidence level implying that the system has been unstandardized. The mean values therefore were not employed for optimization.

V. CONCLUSION

In this research, the energy consumption pattern and predictive model equation for source energy used in local palm oil production was determined. Manual, wood fuel, palm residue, and liquid fuel were the main source of energy input in local palm oil processing mill.

The study shows that wood fuel and palm kernel shell (PKS) fuel are the main source of energy input for local palm oil processing operations.

The ANOVA showed significant difference at 95% confidence level implying that the system is standardized. Therefore, the mean value for all the 4 cases was not employed for optimization.

A predictive model equation was developed for energy source used in the palm oil production to minimize the energy requirement. The equations developed have provided fundamental information for carrying out budgeting and expansion planning, and predicting energy requirement in palm oil production mills.

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