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Characterization Of Small Scale Lumber Saw Mills In A Rural Area In Nigeria

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Abstract

Activities of small scale lumber mills in the rural areas in Nigeria play a vital role in the local economy as a key rural employment generator. Unlike major saw mills in cities which have received lots of attention from researchers, policy makers and the general public, very little information is available on the activities of small scale lumber mills in the rural areas. An assessment of 7 small scale lumber mills was carried out by this study in Ibogun-a cluster of rural settlements in Ifo Local government area of Ogun State Nigeria. Preliminary investigations revealed that 42% of operators used only table saws for their operations while 52% utilized table saws, planning and smoothening machines respectively. The major power source in each of the sites visited was from air cooled diesel engines with 10-15 horse power capacity. Three major lumber sizes were identified as raw materials. The average total Energy expended daily was 318.04 MJ, average daily operational cost was ? 3436.43 ($9.4). Daily power utilization in the conversion process was estimated while the efficiencies of each site in size reduction process ranged from 85-87% respectively.

Keywords: Lumber processing, Rural Development, Energy use

INTRODUCTION

Wood is considered humankind's very first source of energy as it is the most important single source of renewable energy providing about 6% of the global total primary energy supply (FAO, 2017). Wood is the most useful raw material the world has ever known as it remains virtually the predominant material used for construction and energy generation until the last half of the 19th century (Douglas, 1995). The versatile nature of wood has endeared it to multiple forms of domestic and industrial uses (Fuwape, 2003).One of the ways by which the potential end use of wood is maximized is by processing using mechanical machines. Wood is machined to bring it to a specific size and shape for fastening, gluing, or finishing (Ohagwu and Ugwuishiwu, 2011). Wood processing involves peeling, slicing, sawing, and chemically altering hardwood and softwoods to form finished products such as boards or veneer; particles or chips for making paper, particle or fibre product and fuel (Ohagwu and Ugwuishiwu, 2011).

The wood enterprises in Nigeria can be classified into either formal or informal sector enterprises (GWVC, 1994; Fuwape, 2003). The formal sector enterprises include the organized wood based industries such as sawmills, plywood mills, particleboard mills and furniture factories while the informal enterprises are small forest based enterprises operating without formal corporate entity, these include enterprises that engage in the production of firewood, charcoal, chewing stick and sculptured wood items (Fuwape, 2003); in some cases artisanal cabinet makers and lumber converters. The informal sector which is often downplayed in reporting in the wood industry, dominates the industry in terms of number, and is involved in activities which significantly influence trade volume in the formal sector (Ogunwusi, 2014). The major wood processing industries in Nigeria are typically large capacity facilities industries which include timber logging, sawmilling, manufacturing of wood-based panel products (i.e. plywood, fibre board and particle board), furniture making, paper and pulp making, match making, and the manufacture of various wooden items such as tool handles, sport goods, weaving equipment and wooden toys (Sekumade and Oluwatayo, 2011; Owoyemi et al. 2016). The vast majority of the Nigerian populace heavily depends on these industries thus placing pressure on the forest resources of the nation (Aruofor, 2001) which have been rapidly depleting!

Traditionally, timbers have been used to a significant extent in construction purposes and particularly building constructions (Ohagwu and Ugwuishiwu, 2011). One of the major methods of reducing wood logs into useable forms is by saw milling. Sawmilling is defined as the process of converting round wood from the forests into lumbers by using a variety of machines (Aina, 2006). Some of the machines include band mills, capable of breaking down logs into desired specifications and re-sawing machines for processing the cants and flitches into specified and marketable dimensions Lucas (1995). Conversion of timber to lumber of various grades is a major process that is required for the end use of wood products and a major economic activity of most small scale saw mills. Despite this strategic importance, little attention is paid to the performance characteristics and challenges of these enterprises.

In Nigeria, sawmill size is distributed between small: medium: large scale in the percentile proportion (81%: 13%: 6%) respectively (Ogunwusi, 2014). The process of the wood processing from the forest to the saw mill is shown in Figure 1.

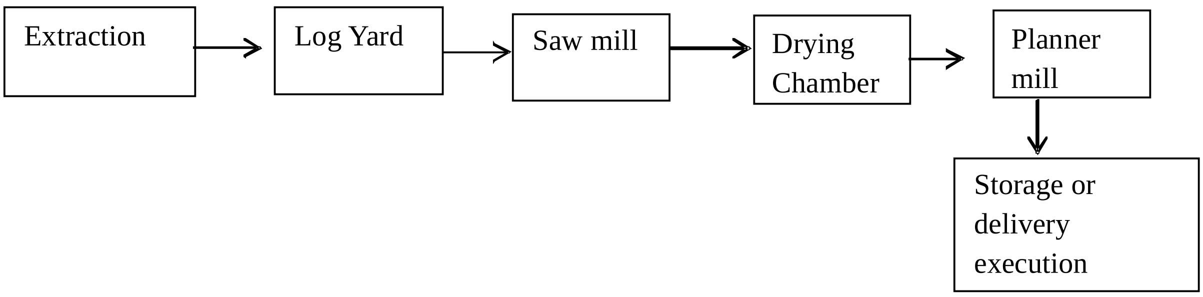

Figure 1: Unit operations of a Typical timber saw mill (Ohagwu and Ugwuishiwu, 2011).

The major problems facing the sawmill industry include (Aruofor, 2001): old equipment and severe shortages of spares, frequent disruption of electricity supply, decline in volume of quality timber size supply and illegal felling and insecurity of tenure with respect to timber concession. The development of the forestry sector is characterized by mechanically processing of timber into sawn wood, veneer and plywood. This promoted the vast growth of the economy by making positive contribution to raw materials production and supply for construction, furniture and packaging (Ogunwusi 2012).

Lumber volume recovery in sawmilling is determined by an array of intertwined interaction of several factors which include (Steele, 1984): Log diameter, length, taper, and quality, Kerf width, Sawing variation, rough green-lumber size, and size of dry-dressed lumber; Product mix; Decision making by sawmill personnel; Condition and maintenance of mill equipment and sawing method. When sawn, a log yields lumber of varying quality which enables end users to buy the quality that best suits their purposes, lumber is graded into use categories, each having an appropriate range in quality (Ohagwu and Ugwuishiwu, 2011).

Several attempts have been made to characterize and estimate the efficiency of the wood conversion process in the major saw mills in Nigeria. Owoyemi *et al.*, (2016), evaluated sawmill generated wood waste, its sustainable management, utilization for bio resources and its clean energy potentials as a viable substitute for fossil fuel based energy sources. Aina *et al.*,(2005) revealed that the conversion rates for the major saw mills was about 57% in the selected study areas of Abeokuta Nigeria. This, they observed, was partly due to the age of equipment used, skill of the operator and the conditions of the wood being processed. They concluded that significant amount of the waste generated from

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these mills could be converted into charcoals which was a major cooking fuel in developing countries and as an alternative to firewood cutting which was a significant cause of deforestation- a major concern for climate change. Ogunwusi (2012), in his evaluation of the performance of the wood industry in Nigeria between 1988 -2010 observed a gradual decrease from 6,994,660m^3 in 1988 to 3,800,000m^3 in 2010 respectively. Despite these significant efforts at highlighting the state of the wood processing industry in Nigeria, little information is available on the energy use pattern of small scale wood processing enterprises, quality control, and work flow management for an effective through put and output. Thus, this study seeks to identify and characterize the operations of the small scale wood milling enterprises in a typical developing country like Nigeria with a view to highlighting their energy use pattern and operational challenges militating against the sustainable growth of the industry so as to provide for qualitative investigation and intervention measures.

MATERIALS AND METHOD

Study Design:

A survey design was adopted for this study in which 7 mills were visited and a total of 20 mill workers were interviewed. Characteristics of each saw mill visited were highlighted and these include: raw materials storage and handling, mill capacity, number of workers, milling operations and the equipment used. Correlation between the feed mill capacity and the number of workers for the population was determined at 5% level of significance (Adetifa and Oyewole, 2015). The study area of this research at Ifo Local government area of Ogun state located between coordinates 6.8192° N, 3.1930° E. The saw mill workers were interviewed using specially designed questionnaires.

Data collection and analysis

In identifying and defining other characteristics, four key areas were considered and they include (Adetifa and Oyewole, 2015):

Power source: The source of power for the milling operations was investigated to determine the power consumption and the cost.

Unit operations and equipment: The prevailing unit operations such as drying, storage, saw milling, materials handling equipment etc., were investigated and studied to determine the performance of each of the operation and their respective equipment.

Energy utilization: In estimating the energy available and consumed, the following empirical formulas reported by Abubakar and Umar (2006) and Adetifa and Oyewole (2015) were used

- **Evaluation of Manual Energy Input**: Manual energy input was estimated from Equation 1 and Equation 2;

$$EM_m = 0.75T_\alpha \quad (1)$$

$$EM_f = 0.68T_\alpha \quad (2)$$

Where: *EMm* is the male manual energy input (MJ). *0.75* is the Energy input of an average adult male (MJ/h) (Norman, 1978). *Ta* represents the useful time spent by a male worker (h).

EMF is the female manual energy input (MJ) and *0.68* is the Energy input of an average adult female (MJ/h). *Ta* represents the useful time spent by a female worker (h).

- **Liquid Fuel Energy:** Liquid fuel energy was estimated using Equation 3 below

$$E_{FLD} = 36.4D \quad (3)$$

Where: E_{FLD} represents the liquid fuel energy input for diesel (MJ) and *D* is the amount of diesel consumed (in Litres).

- **Electrical Energy (EE)**: Data on electricity consumption (kWh) would be estimated from the past bills collected over the year. These values would be converted into common energy unit (MJ) by using appropriate coefficient (one-kilowatt-hour of electricity = 3.6 MJ) i.e. Equation 4

$E_E = 3.6 \times kWh$ (4)

- **Total Energy**: Assuming negligible maintenance energy, the total energy was estimated from Equation 5 below.

$E_T = E_M X + E_{FL} + E_E$ (5)

Where $E_{M,}$ $E_{FL,}$ and E_E represent the Manual Energy, Fuel Energy and Electrical Energy respectively

- **Power Requirement**: The cutting power P_c can be expressed as follows:

$$Pc = \frac{\text{Energy Utilized}}{\text{time}} \quad (6)$$

✍ Capacity = N x L x B x T (7)

where N,L ,B and T are number of lumbers and lumber length, breadth, and Thickness dimensions respectively.

The energy contents of some common fuel are highlighted in Table 1.

Table 1. Energy Values of Common Fuel

Fuel	Unit	MMBtu/unit
Diesel	Gallons	0.1387
Gasoline	Gallons	0.1242
Propane	Gallons	0.0913
Natural gas	Dekatherm	1.0000
Electricity	kWh	0.0034

(Loeffler et al. 2016)

Microsoft Excel was used to analyse the data obtained.

RESULTS AND DISCUSSION

The sizes of lumber that serve as raw materials into the saw mills are dimensioned in length, breadth and thickness. All the Lumbers have a uniform length of 3.7 m. The sizes of lumbers include: 50.8 mm by 152.4 mm (2inches by 6) denoted by size A, 50.8 mm by 304.8 mm (2inches by 12inches) as size B and 25.4 mm by 304.8 mm (1 by 12 inches) denoted by size C respectively.

Power source Unit Operations and Equipment:

The source of power for the operations in the visited sites was alternative power in form of diesel heat engine. The unit operations involved

- Delivery and offloading of lumbers from major saw mills in Abeokuta and Lagos.
- Conveyance of the lumbers into a storage facility where they are also air dried.
- Milling of the lumbers into sizes to meet end user specifications.

Preliminary observations revealed that the major sectors that the saw mills serviced were primarily building construction and furniture making while their wastes were a major source of fuel for domestic cooking an observation confirmed by Aina *et al*., (2006), Ogunbode *et al*., (2013) and Loeffler *et al*, (2016). The major raw materials in all the sites visited were lumbers of the following tree species which are locally known as: Mahogany, Iroko, “Malaina” “eki”, “oridudu”, “Iya”, “Agan”, “Arugba”, “Ayunre”, and “Itara” respectively.

Some of the sites visited are shown in Figure 2. Not all the operators were open to picture taking. Hence the pictures shown were taken with full the consent of the operators.

Figure 2: Some milling equipment at sites visited.

Energy utilization

Table 2 highlights the types of equipment and number of employees available in the sites visited while the daily operational characteristics of the mills are shown in Table 3. The manual energy obtainable from an adult male worker is shown in Figure 3.

Table 2. Equipment Types and Number of Employees

Sawmill number	Equipment Available	Power source	Number of Employees
1	Table saw	10 hp air cooled Diesel Engine	4
2	Table saw and plane machine	10 hp air cooled Diesel Engine	2
3	Table Saw and Plane Machine	15 hp air cooled	2
4	Table saw	10 hp Air Cooled Diesel Engine	3
5	Table saw ,plane and sprindle	10 hp Air cooled Diesel Engine	3
6	Table saw Plane machine	, 10 hp Air cooled Diesel Engine	3
7	Table saw	Air Cooled	3

Source: Field Work

Table 3: Some Operational Characteristics of Sawmills

Sawmill	Daily Fuel use in (litres)	Fuel Cost@ ₦215/Litre	Average Daily Operational Hours	Daily Labour Cost@₦20 per sawn lumber
1	7	₦1505	5±0.5	₦1500
2	6	₦1290	6±0.5	₦1200
3	10	₦2150	5±0.5	₦2000
4	7	₦1505	5±0.5	₦1400
5	10	₦2150	5±0.5	₦2000
6	10	₦2150	6±0.5	₦1900
7	7	₦1505	5±0.5	₦1800

(Source: Field Work)

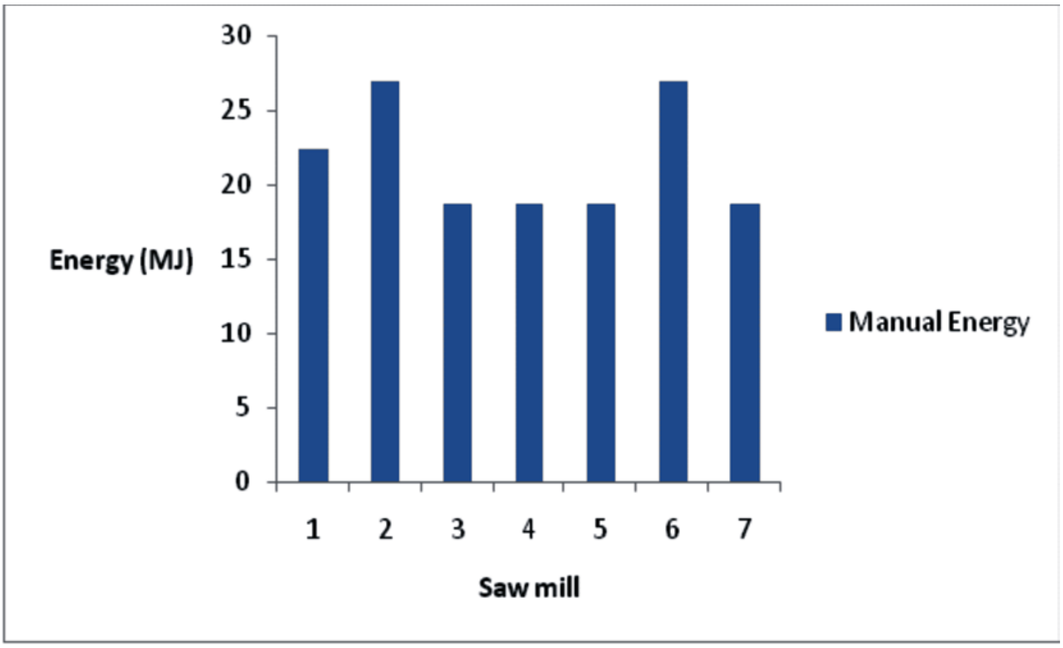

Figure 3: Daily Manual Energy from each site.

The predominant operators that man the equipment are the male workers. Female workers in all sites visited were limited to wood handling and storage of lumbers but not allowed to operate or go near an operational milling machine. The main activity involves reducing the lumber into specifications required by the customers.

None of the sites visited was connected to the public power supply. Operators identified erratic power supply, exorbitant monthly bills not commensurate with services provided and perennial low voltage which might not be able to power their milling equipment as major reasons for not attempting to connect to the grid. On the average, the saw mills work for 6 days a week and on an average of 5 hours per day. The average cost of fuel per day is ? 1750.7 ($4.86) while the average labour cost is ? 1685.7 ($4.68) which makes the total daily operational cost to be ? 3436.4 (about $10). The energy obtainable from diesel fuel use is presented in Figure 4 while the total energy usage per site is shown in Figure 5.

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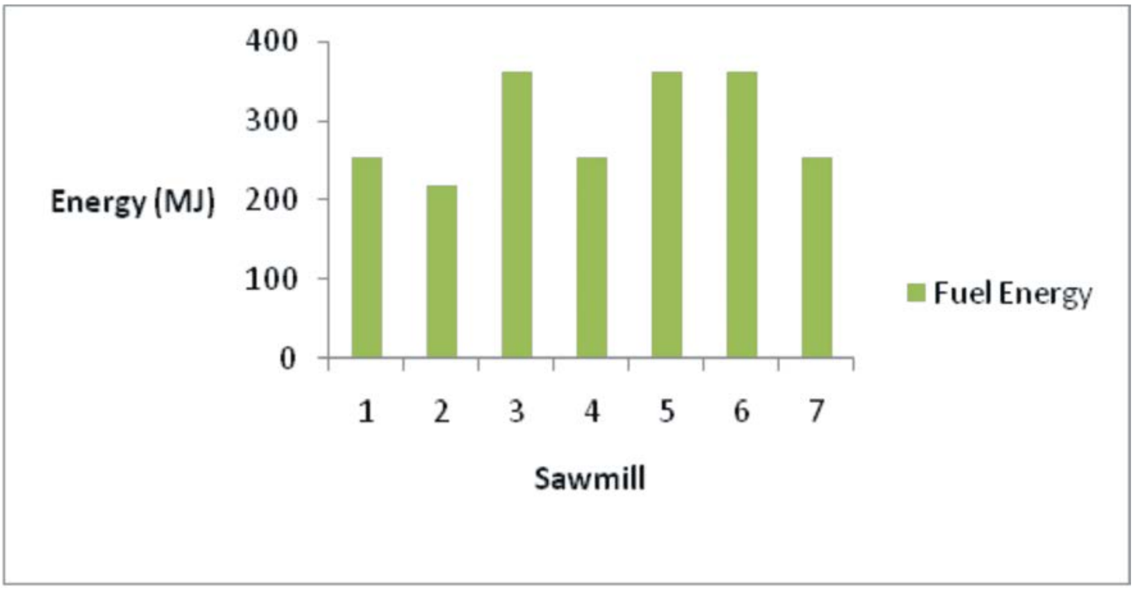

Figure 4: Energy Utilized from the Liquid Fuel (diesel) per site.

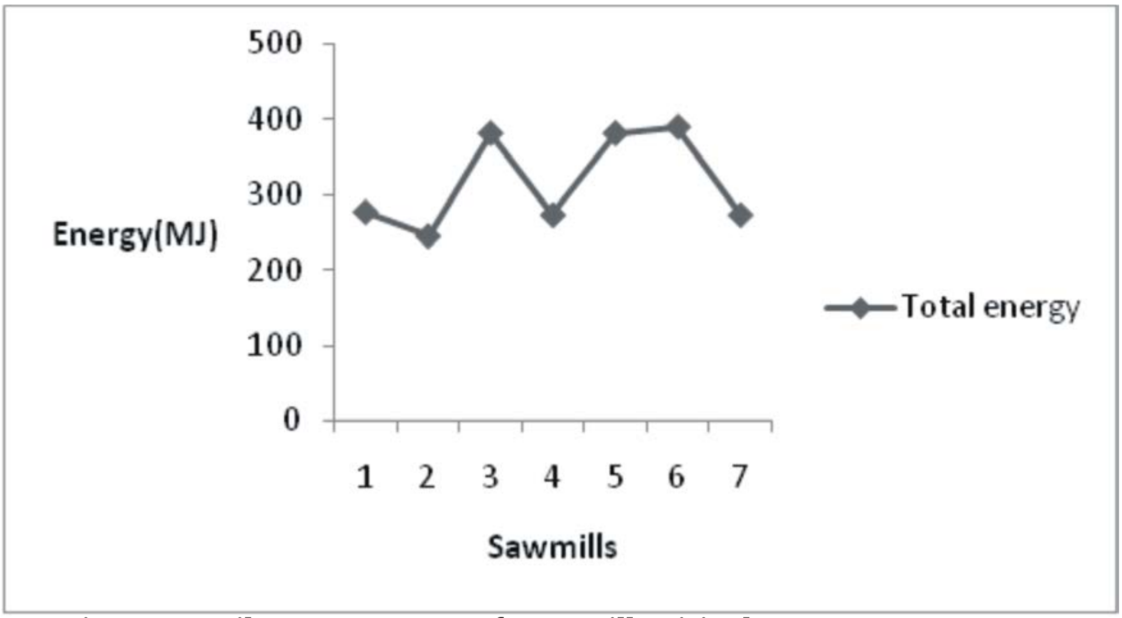

Figure 5: Daily Energy Usage of Saw Mills Visited

Since the efficiency of the internal combustion engine is about 15-20% on the average, this is expected to impact on the energy requirement it is expected that the real energy useful in the size reduction procedure will be less than the shown values.

Capacity of Mills

The Average capacity of the mills was found to be 2.46 $m^3$of lumber per day. The correlation of capacity of each mill with the employee shows that there was very weak interaction between the number of employees and the sawmill capacity at 0.04.

The capacity of a mill was highly dependent on a number of factors which include:

- Availability of skilled and experienced operators: because of the high turnover of employees in the sector, the best hands are rarely affordable to the small scale enterprises hence majority of the owners operate the saw mills alone or with the help of relatives to keep operational cost low.
- **Fuel Scarcity:** Due to their heavy dependency on diesel fuel the operators are highly vulnerable to the effects of fuel scarcity and fluctuating diesel price

in the open market.

- **Demand driven market:** times of strong demands usually coincide with the dry season when building construction activities are at their peak. The operators could work well into the night so as to meet up with clients order.
- **Declining Wood Quality and Limited Storage Facilities:** Most of the operators agreed that the quality of wood coming from the forests was declining thus making them to make do with the available. They also have limited storage facilities which also serve as the drying chamber for their lumbers.

Power Requirements

The power required in reducing the different units of identified sizes of lumber in each site visited is given in Figure 6. The maximum power utilization per site visited was 2.1 kW and saw mill 6 utilized this maximum daily power

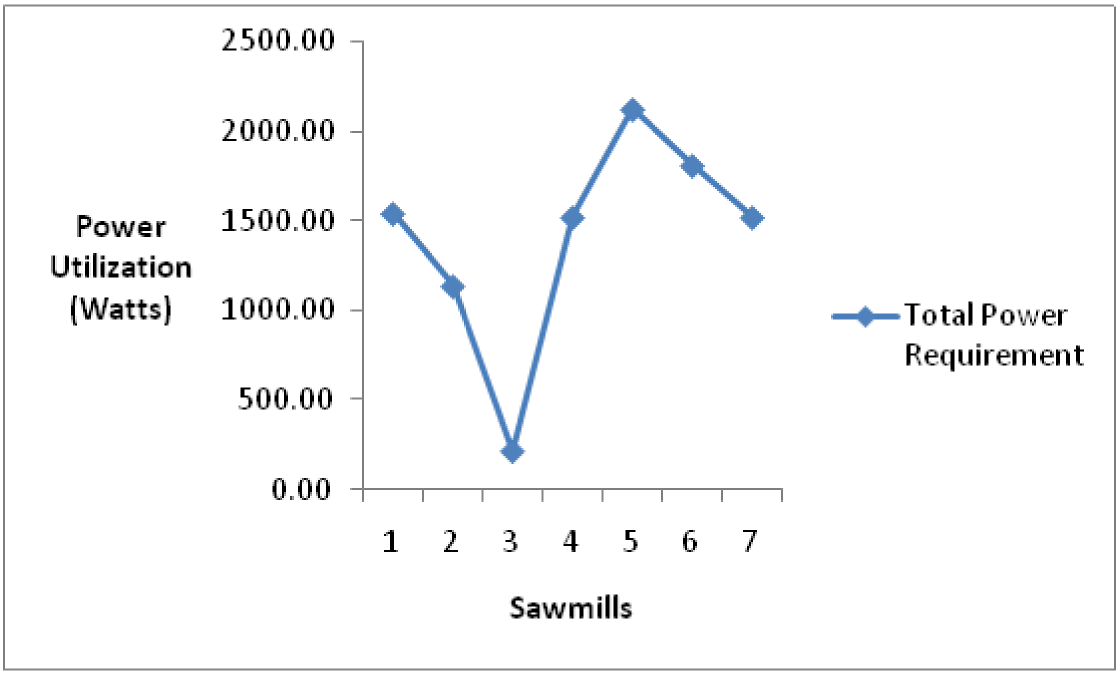

Figure 6: Power utilization in Size reduction

Analysis of variance (ANOVA) was used to measure the level of interaction in the power utilization in the saw mills and the results are presented in Table 4.

Table 4: ANOVA of Power Utilization in Various sawmills

Source of Variation	SS	df	MS	F	P-Value	F-Crit
Between Groups	543771.1	4	135942.8	51.62502	4.99E-13	2.689628
Within Groups	78998.19	30	2633.273			
Total	622769.3	34				

The P-value indicated a very low possibility that our data were due to chance and there was a significant difference in the power utilization patterns of the mills visited as the F-value was more than the confidence interval of 0.05.

Efficiency of milling operation and Waste Generation

The major waste generated from the lumber mill activities is the saw dust and the efficiency of each mill visited in reducing the lumber sizes A, B and C ranged from 80-85%.

The preferred ways of disposal of waste generated include: evacuation by other end users such as poultry farmers to be used as litters, cooking fuel for small scale food vendors, research students who use them as raw materials and burning.

CONCLUSION

A preliminary investigation was carried out to assess the energy use pattern of small scale saw mill in a rural area. 100% of the sites visited were powered by alternative power supply in the form of diesel engines. The most important activity in the small scale saw mills visited was size reduction of lumbers and this was primarily responsible for the overall power consumption of the mills. The Total energy utilized and cost during the procedure were estimated and presented. The power requirement was also obtained.

RECOMMENDATION

The challenges of small scale milling industries have been discussed and the following recommendations are made.

- Off grid renewable energy solution can be developed for a more reliable power supply in a sustainable manner.
- Special concession in terms of billings and should be made to the operators by electricity companies who should also ensure power is available to the operators for at most 5 ½ hours daily.
- Skills and Training Programmes should be developed/resuscitated to address the limited man power challenges in the sector.

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