Annals of Technology Education Practitioners Association of Nigeria
ATEPAN (December, 2024) 7(4), 136-143
ISSN: 2645-2839 (Print)
eISSN: 2645-2847 (Online)

ELECTRICAL ENERGY USE EFFICIENCY IN WOODWORK INDUSTRIES IN KATSINA STATE, NIGERIA

Mansur, A. D., Saba, T. M., Yisa S. N. & Musa, S.
Department of Industrial and Technology Education, Federal University of Technology, Minna
Corresponding E-mail: aminamansurdarma@gmail.com (Tel: +2347039294824)

Abstract: *The study determined the electrical energy use efficiency in woodwork industries in Katsina State, Nigeria. Two research questions guided the study, descriptive survey research design was adopted. The target population of the study was 454 registered furniture industries. Multistage sampling method; stratified random sampling technique and simple random sampling was used to sampled 132 wood industries. The data collected through observation check-list were analysed using the Microsoft office Excel computer programme and values and percentages were used to present the results of the research questions, a tariff rate of ₦46.51Kilowatt hour (KWh) and Value-Added Task (VAT) of 7.5% were used for the study area. The findings of the study revealed that woodwork industries in Katsina State consumed 106.9 KWh for lightings, 22,079.4 KWh for operating machineries. The total electrical energy consumed was 22,186.3 KWh, with the use of recommended efficient electrical lighting the consumption dropped to 36.3 KWh saving 71.9KWh that is 66.5%. The amount of electrical energy bill that will be saved is ₦3,549.9 per day and ₦106,497.00 per month. While consumption from electric motors dropped to 17,582.6 KWh saving 4,496.8 KWh that is 20.4%. The amount of electrical energy that will be saved is ₦152,666.00 per day and ₦4,579,992.00 per month. It was therefore recommended among others that the woodwork industries owners should carryout appropriate electrical energy audit and economic evaluation of the electricity used to reduce the rate of energy wastages.*
Keywords: *Electrical energy, woodwork industries, efficiency*

Introduction

Electrical energy is energy derived as a result of movement of electrically charged particles. electrical energy refers to energy that has been converted from electric potential energy. Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical or other forms. According to the law of conservation of energy, the total energy of a system remains constant, though energy may transform into another form. Electrical energy is supplied by the combination of electric current and electric potential that is delivered by an electrical circuit (provided by an electric power utility). At the point that this electric potential energy has been converted to another type of energy, it ceases to be electric potential energy. Thus, all electrical energy is potential energy before it is delivered to the end-use (Shafie, *et al,* 2021). Electrical energy is usually sold in kilowatt hour which is the product of the power in kilowatts multiplied by running time in hours. Electric utilities measure energy using an electricity meter, which keeps a running total of the electric energy delivered to a customer such as wood industries.

The wood industries include manufacturing of furniture parts and their assembly with appropriate finishing operations. Basic materials in the industry are wood and wood-based materials. Ahmed *et al,* (2022) stated that the level of specific electrical energy consumption (energy consumed per unit of finished product) in wood industries depends on the manufacturing processes that are implemented in wood industries, the type of material being processed, applied woodworking technology, scale and type of production, the type of furniture that is produced, and so forth. The wood industries are relatively huge energy consumer bases on the classifications of International Energy Agency (Mate, 2002). According to the systemization of data for different industries, the mean specific consumption of primary energy in the wood processing industries, which includes the production of wood furniture is much. The wood processing facilities differ with respect to each other in terms of manufacturing processes, energy consumption, and the potential for energy efficiency measures (Ahmed *et al,* 2022).

Electrical energy costs in an energy non-intensive industrial company (such as a furniture industry company) are often considered as fixed overheads, although they belong to the cost categories that can be easily managed. According to McCoy (1997), the wood products industry consumed more than 3.1 quads of energy in developing countries as Nigeria. However, due to the constant growth of energy prices, industrial companies in the industry become increasingly aware that the energy is an expensive commodity and therefore it should be used effectively in order to increase company's profit (McCoy, 1997). Saba, *et al* (2015) stated that the development and implementation of energy efficiency measures is certain to reduce operating costs in wood processing and hence enhance the competitive edge of such manufacturing enterprises. Therefore, wood industries become more motivated to introduce the practice of energy management as a part of their regular activities. The development of a profile for wood processing facilities will aid in identifying the potential for energy efficiency measures and subsequent implementation.

Electrical energy efficiency use, sometimes simply called energy efficiency, is the process of reducing the amount of energy required to provide products and services. According to Shafie *et al* (2021), energy efficiency is the use of less energy to perform the same task or produce the same result. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods. Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily increasing energy consumption. The practices of energy efficiency use allow the use of less energy demand to achieve and maintain the wood industries operations. Installing light-emitting diode bulbs, fluorescent lighting, or natural skylight windows reduces the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process or by application of commonly accepted methods to reduce energy losses.

The issue of energy efficiency has recently become a critical one in all aspects of national development, particularly housing. This is because energy represents not only a high percentage of the running cost of a building but it also has a major effect on the thermal and optical comfort of the occupants. In Nigeria, the industrial sector is the highest energy/power consumption sector of the economy and is associated with energy efficiency problems. Most industrial appliances and lighting are electrically operated and constitute a major part of the energy consumption bill. To adequately address this issue, the energy performance of industries such as wood industries needs to be improved upon.

Therefore, to accomplish an industry which has low energy running and maintenance costs, energy efficiency must be taken into consideration at every stage of the design process. The implication of attaining energy efficiency is that the management of wood industries can lower energy cost, due to added benefits of lower running and maintenance costs that accompany energy efficiency (Oke *et al.*,2021). A careful selection of electrical appliances can have a dramatic effect on energy consumption and the operational costs of wood industries. Though, increasing number of electrical appliances tends to raise energy consumption, but improving efficiencies of appliances and lighting will tend to reduce consumption.

The management of wood industries can therefore do much to cut energy costs due to lighting and other appliances by specifying and installing low energy lighting and appliances. According to Edinformatics. (2023) the energy consumption of wood industries is more uncertain because variations in their type and power cannot be predicted, and also the variation in the schedule of use of the different industrial appliances, and the consumption. But recent developments in energy technology have made it possible to decrease significantly the energy consumption of machines, to create industries that implement a major decrease in emissions to the environment. However, the continuing shortfall between electricity demand and supply and the competing needs for investment capital are some of the few obvious reasons why Nigeria should have improved energy-efficient industries.

Moreover, the prevailing rampart power shortages are attributable in part to peak demands caused majorly by lighting and use of other higher energy consuming machines in the wood industries. Continued effort by the government in establishing a lasting sustainable financial structure and incentives for energy-efficient products backed up with formidable policies and public awareness programme in this direction can help abate the electrical energy efficiency problem (Ling-zhi *et al*. 2018). According to Daniel *et al*. (2021), electrical machines and lighting represent the bulk of industries (including wood industries) energy use growth area, and has been witnessing increasing consumption levels in Nigeria. This implied that wood industries in Nigeria need to adopt electrical energy management to enhance industrial growth.

The economic evaluation of electrical energy is the process of systematic identification, measurement and valuation of the inputs and outcomes of electrical energy used. According to Ling-zhi *et al.* (2018), the purpose of economic evaluation of electrical energy is to identify the best course of action based on the evidence available. The method used to conduct economic evaluation of electrical energy is to calculate the net economic value of unit electric energy provided by the generation resources through the difference between the average electricity prices. Ling-zhi *et al*. (2018) disclosed that the highly capital-intensive electricity supply to woodwork industries, demands for economic evaluation of electrical energy. Nevertheless, this could form a solid basis for improving electrical energy savings in woodwork industries.

Statement of the Problem

Woodwork industries consume a substantial amount of energy because of the nature of their daily operations. Electrical energy wastages in woodwork industries are bigger threat to the economy development of the country. According to Adam (2016), the major causes of electrical energy wastage in woodwork industries are use of inefficient equipment (electrical motors) and lighting practice. Sensorfact (2023) stated that the use of inefficient motors in woodwork industries is a big waste of energy because they consume a lot of electricity even when they are not being used. This results in higher energy bills that deny the woodwork industries from achieving full potentials of electrical energy savings.

It is therefore worth researching on areas where electric energy is wasted and how to reduce the wastage considering the fact that woodwork industries require electrical energy to drive machines and other equipment. This study sought to determine the electrical energy efficiency use and saving opportunities for the woodwork industries in Katsina State, Nigeria.

Purpose of the Study

The main purpose of this study was to determine the electrical energy used in woodwork industries in Katsina State. Specifically, the study is to determine;

4. Total amount of electrical energy used in woodwork industries in Katsina State.
5. Economic evaluation of the use of efficient electrical appliances in woodwork industries in Katsina State.

Research Questions

The following research questions guided the study.

1. What is the total amount of electrical energy used in woodwork industries in Katsina State?
2. What is the economic evaluation of the use of efficient electrical machines/appliances in woodwork industries in Katsina State?

Methodology

The study adopted the use of descriptive survey research design. Bostley (2019) defined descriptive survey research as a purposive process of gathering, analyzing, classifying, and tabulating data about prevailing conditions, practices, processes and trends. This is because the study sorts the opinion of the respondents in the woodwork industries in Katsina State. Descriptive survey research use surveys to gather data about varying subjects. Descriptive research is used to obtain

information concerning the current status of the phenomena and to describe "what exists" with respect to variables or conditions in a given time.

The study was carried out in Katsina State, Nigeria. The geographical Location of Katsina State is between: Lattitudes12-º13 º N and Longitudes 7º-9º E. The target population of the study was 454 registered furniture industries. The study sampled 132 woodwork industries. The instrument that was used for data collection was a structured questionnaire titled Electrical Energy Efficiency and saving opportunities for the woodwork industries; The data collected through observation check-list were analysed using the Microsoft office Excel computer programme and values and percentages were used to present the results of the research questions, a tariff rate of ₦46.51Kilowatt hour (KWh) and Value-Added Task (VAT) of 7.5% were used for the study area.

Results

Table 1a Amount of Electrical Energy Use in Woodwork Industries in Katsina State

LIGHTINGS

S/N	Types	Wattage	Quantity	Hours/ Day	Total (KWH)
A	Light Emitting Diode (LED)				
1		5w	258	3.3	4.3
2		10w	336	2.3	7.7
3		15w	124	2.1	3.9
4		20w	103	2.1	4.3
5		25w	92	2.8	6.4
B	Compact Florescent Light (CFL)				
1		35w	25	3.0	2.6
2		100w	143	3.2	45.8
3		150w	41	0.5	3.1
4		200w	27	2.1	11.3
C	Halogen Lamps				
1		250w	12	3.3	9.9
2		400w	1	4.0	1.6
3		500w	2	6.0	6.0
	TOTAL		1,164		106.9

Table 1a indicated that lighting such as Light Emitting Diode (LED), Halogen Lamps and Incandescent Lamps with their power ratings in watts and the total number of hours they all work per day each in wood work industries in Katsina State. The total amount of electrical energy used in woodwork industries for lighting is 106.9 KwH.

Table 1b Amount of Electrical Energy Use in Woodwork Industries in Katsina State

ELECTRIC MOTORS

S/N	Horse Power (HP)	Wattage	Quantity	Hours/ Day	Total
1.	.50	373	16	5. 6	33,4
2.	.75	560	8	3.3	14.8
3.	1	746	28	2.9	60.6
4.	1.5	1119	24	3.4	91.3
5.	2	1492	10	4.4	65.6
6.	3	2238	37	4.4	334

7.	5	3730	25	4.4	410
8.	7	5222	5	2.8	73.1
9.	7.5	5595	108	5	3021.3
10.	8	5968	2	5	59.7
11.	10	7460	63	3.4	1597.9
12.	14	10444	13	8.9	1208.4
13.	15	11190	16	5.3	948.9
14.	20	14920	35	7.6	3968.7
15.	25	18650	29	6.9	3731.9
16.	30	22380	4	3.5	313.3
17.	40	29840	25	2.5	1865
18.	50	37300	19	1.2	850.4
19.	60	44760	13	0.8	465.5
20.	75	55950	05	4.2	1174.9
21.	100	74600	05	4.8	1790.4
	TOTAL		490		22,079.4

Table 1b indicates the total amount of electrical energy consumed by electric motors with their horse power, wattage, quantity and the total number of hours they all work per day each in wood work industries in Katsina State. The total amount of electrical energy used for lighting is106.9 KwH and for electric motors is 22,079.4 KwH. The total amount of electrical energy used in woodwork industries of Katsina State by both the lightings and electric motors is 22,186.3 KwH.

Table 2a Economic evaluation of the use of efficient electrical machines/appliances in woodwork industries in Katsina State

LIGHTINGS

Types	**Wattage**	**Quantity**	**Hours / Day**	**Total**	**Alternative Rating**	**Total**	**Energy Saved**
LED 1	5	258	3.3	4.3	-	-	-
2	10	336	2.3	7.7	5	3.9	3.8
3	15	124	2.1	3.9	10	2.6	1.3
4	20	103	2.1	4.3	15	3.2	1.1
5	25	92	2.8	6.4	20	5.2	1.2
CFL1	35	25	3	2.6	25	1.9	0.7
2	50	6	4.2	1.3	25	0.6	0.7
1	100	143	3.2	45.8	25	11.4	34.4
3	150	41	0.5	3.1	25	0.5	2.6
4	200	27	2.1	11.3	25	1.4	9.9
Halogen lamp1	250	12	3.3	9.9	25	0.9	9.0
2	400	1	4	1.6	25	0.1	1.5
3	500	2	6	6	25	0.3	5.7
TOTAL				**108.2**		**36.3**	**71.9 66.5%**

Table 2b Economic evaluation of the use of efficient electrical machines/appliances in woodwork industries in Katsina State

ELECTRIC MOTORS

Horse Power	**Wattage**	**Quantity**	**Hours /Day**	**Total**	**Alternative Rating**	**Total**	**Energy Saved**
0.50	373	16	5.6	33.4	-	-	-
0.75	560	8	3.3	14.8	0.5	9.8	5.0

1	746	28	2.9	60.6	0.75	45.4	15.2
1.5	1,119	24	3.4	91.3	1	60.9	30.4
2	1,492	10	4.4	65.6	1.5	49.2	16.4
3	2,238	37	4.4	334	2	242.9	91.1
5	3,730	25	4.4	410	3	2,46.2	163.8
7	5,222	5	2.8	73.1	5	52.2	20.9
7.5	5,595	108	5	3021.3	7	2819.9	201.4
8	5,968	2	5	59.7	7.5	56.0	3.7
10	7,460	63	3.4	1,597.9	8	1,278.3	319.6
14	10,444	13	8.9	1,208.4	10	863.1	345.3
15	11,190	16	5.3	948.9	14	885.7	63.2
20	14,920	35	7.6	3,968.7	15	2,976.5	992.2
25	18,650	29	6.9	3,731.9	20	2,985.5	746.4
30	22,380	4	3.5	313.3	25	261.1	52.2
40	29,840	25	2.5	1,865	30	1,398.8	466.2
50	37,300	19	1.2	850.4	40	680.4	170
60	44,760	13	0.8	465.5	50	387.9	77.6
75	55,950	05	4.2	1,174.9	60	940	234.9
100	74,600	05	4.8	1,790.4	75	1,342.8	447.6
TOTAL		**490**		**22,079.4**		**17,582.6**	**4,496.8 20.4%**

The economic evaluation of the use of efficient appliances such as lamps, by replacing compact fluorescent light and halogen lamps with alternative LED lamps, about 71.9 KwH of electrical energy can be saved as shown in the Table 2a above, instead of 7,108.2kwH consumed by the fluorescent lamps and halogen lamps, 36.3kwH of electrical energy can be used by replacing with the alternative LED which gives 66.5% of saved energy in the woodwork industries in Katsina State. When these values converted to Nigerian Naira with a tariff rate of ₦46.51/ KwH used in the study area, the total tariff was ₦ 5032.4 at 7.5% VAT the total was ₦5,409.8 by using alternative LED ratings it was changed to ₦1688.3 at 7.5% VAT was equivalent to ₦1,814.9 which saves ₦3,549.9 a day.

On the other hand, Table 2b indicated that total amount of electrical energy consumed by electric motors in woodwork industries was found to be 22,079kwH by replacing high electrical energy consumption electric motor with alternative horsepower, about 17,582.6kwH can be used. It is also seen that calculated to be 20.4% can be saved per day. When converted to Nigerian Naira each Kilowatt hour sold at ₦46.51 including 7.5% VAT was ₦749,595.6 by using alternative power rating it will be ₦596,929.2 which will also save the total amount of ₦152,666.40 of electrical energy.

Findings of the Study

1. The finding revealed that woodwork industries in Katsina State consumed 106.9 KwH for lightings 22,079.4 KwH for operating electric motors. The total electrical energy consumed was 22,186.3 KwH.

2. With the use of efficient electrical lighting the consumption will dropped to 36.3 KwH, saving 71.9kwH that is 66.5%. The amount of electrical energy that will be saved is ₦3,549.9 per day, ₦106,497.00 per month. While consumption from electric motors will be dropped to 17,582.6 KwH, saving 4,496.8 KwH that is 20.4%. The amount of electrical energy that will be saved is ₦152,666.00 per day and ₦4,579,992.00 per month.

Discussion of the Findings

The amount of electrical energy consumed was 106.9 KwH for lightings. 22,079.4 KwH for operating electric motors. The total electrical energy consumed was 22,186.3 KwH. Oke and Diji (2019) discovered that the cost of energy per volume for the seven species of wood in their study area. The Iroko wood a hard wood of density 653.66 Kg/m^3 is the predominant wood specie that is processed for log in the study area and has the highest average energy per unit volume of 4.48 KwH /m^3. While the Omo and Obeche wood are the least wood processed with smallest average per unit of 0.75kwH/ m^3.and 0.58 KwH respectively. The only noticeable contrast is that of Opepe wood which is hard like Iroko and high density of 739.45Kg/m^3 had an average energy per unit of 1.77 KwH /m^3.

The study indicated that with the use of efficient electrical lighting the consumption dropped to 36.3 KwH, saving 71.9 KwH that is 66.5%. The amount of electrical energy that will be saved is ₦3,549.9 per day, ₦106,497.00 per month. While consumption on electric motors dropped to 17,582.6 KwH, saving 4,496.8 KWh that is 20.4%. The amount of electrical energy that will be saved is ₦152,666.00 per day and ₦4,579,992.00 per month. This is in line with Kiprotich (2018) that discovered a total of 659303.51 KwH (44.9%) of energy could be saved every year by replacing all T8 linear fluorescent lamps in Eldoret University Kenya with T8 linear LED lamps. The unit cost of electric energy for commercial industrial one (CI1) consumer such as universities is Ksh. 9.20 (KPCL,2017). Therefore, energy saved would translate to saving (9.20 × 659303.5) per annum. Kiprotich added that there was electric energy saving potential of up to82% at Universities in Kenya that could be achieved through replacing T8 linear fluorescent lamps with T8 LED lamps.

Conclusion

Conclusively, the study, insights on electrical energy use efficiency in woodwork industries in Katsina State, Nigeria was provided. The study revealed that 1,164 lightening bulbs with their power ratings in watt and the total number electrical energy consumed was 106.9 KwH per day in wood work industries in Katsina State. The study found that 490 electric motors with their horsepower and the total number electrical energy consumed was 22,079.4 KwH in which they usually work per day in wood work industries in Katsina State. The study also found out that with the use of efficient electrical lighting the consumption will dropped to 36.3 KwH saving 71.9 KwH that is 66.5%. The amount of electrical energy that will be saved is ₦3,549.9 per day, ₦106,497.00 per month. While consumption from electric motors will also drop to 17,582.6 KwH saving 4,496.8 KwH that is 20.4%. The amount of electrical energy that will be saved is ₦152,666.00 per day and ₦4,579,992.00 per month in the woodwork industries in Katsina State.

Recommendations

Based on the findings from the study, the following recommendations were made:

1. The woodwork industries stakeholders should always calculate the amount of electrical energy consumed by the electrical appliances and equipment. This will help in knowing the electrical energy consumed and the amount to be paid for the power used.
2. The woodwork industries personnel should ensure appropriate electrical energy audit and economic evaluation of the energy used. This can be achieved by calculating electrical energy used and alternative electrical energy equipment and appliances.

References

Adam, S. (2016). *The five Biggest Causes of Wasted Energy*. Retrieved from: https://www.electroind.com/5-biggest-causes-of-wasted-energy/

Ahmed, H. O.; Saba, T. M. & Idris, A. M (2022) Electrical energy saving approaches adopted in General Hospitals in Kogi State, Nigeria. *Journal of Information, Education, Science and Technology (JIEST) Vol .8 (1) 56-63*

Bostley, M. A. (2019). Basics of research design: A guide to selecting appropriate research design. *International Journal of Contemporary Applied Researches 6 (5) 76-89*

Daniel, B. C., Saba, T. M., Kagara, A. B. & Yisa, S. N (2021) Skills Gap of Industrial Electricians towards Efficient Management of Electric Motors in Industries in Kaduna State, Nigeria. *Wudil Journal of Faculty of Science and Technology Education (WUJOSTEC)*

Dunning, S. & Todd, W. (1998). Energy and waste saving measures for the paper and wood products industry." *In IEEE Conference Record of Annual Pulp and Paper Industry Technical Conference*

Edinformatics. (2023). *How to Calculate Electric Power and Energy*. Retrieved 3rd February, 2023 from: https://www.edinformatics.com/math_science/electric-power-equations.html.

Gosselin, A., Blanchet, P., Lehoux, N., & Cimon, Y. (2017). Main motivations and barriers for using wood in multi-story and non-residential construction projects. *BioResources, 12*(1), 546-570. DOI: 10.15376/biores.12.1.546-570

Kiprotich W.M. (2018) *Potential for Saving Eectrical Energy in Kenyan Universities using Technological and Behavioural Techniques.* Kenya: University of Eldoret, Eldoret Kenya.

Ling-zhi, R., Xin-gang, Y., Xin-xuan, Z., and Yu-zhuo, Z. (2018). Cost-benefit evolution for concentrated solar power in China. *J. Clean Prod.* 190, 471–482. doi: 10.1016/j.jclepro.2018.04.059

Mate, A. A (2002). Energy Analysis and Diagnostics in Wood Manufacturing Industry. *Thesis*, West Virginia University.

McCoy, G. (1997). Motor Master: An energy-efficient motor selection and energy management tool for the pulp and paper industry. *In IEEE Conference Record of 1997 Annual Pulp and Paper Industry Technical Conference*. Cincinati USA pp 29-35

Oke, A. O & Diji, C. J. (2019) Energy analysis of Timber Log Processing in Nigerian Sawmill. *Journal of Energy Management and Technology (JEMT) 3(2),9-13*

Oke A. O. (2021). Energy Audit of Timber log processing in Southwestern Nigeria. Afribary.com

Saba T. M., Tsado J., Bukar, B., & Bello, H. (2015). Technology approach to electrical energy management in small and medium enterprises in Niger State, Nigeria. *ATBU Journal of Science Technology and Education* 3(3). 92-101

Sensorfact, D. (2023). *What is wasted energy – 5 common types of energy waste*. Retrieved 3rd February, 2024 from: https://www.sensorfact.eu/blog/what-is-wasted-energy-5-common-types-of-energy-waste/

Shafie, S. M., Nu'man, A. H. & Yusuf, N. N. A. N. (2021) Strategy in Energy Efficiency Management: University Campus. *International Journal of Energy Economics and Policy.*11(5), 310-313.

State and Local Solution Center. (2023). *Energy Efficiency Potential Studies Catalog*. Retrieved 3rd February, 2023 from: https://www.energy.gov/scep/slsc/energy-efficiency-potential-studies-catalog#:~:text=Energy%20efficiency