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Energy Management Practices in the Sawmill Industry in Ghana

Abstract: The sawmill industry is vital for Ghana's economic development but faces challenges in energy efficiency. This study evaluates energy consumption patterns in the Sunyani Municipality's sawmill industry to identify cost-saving opportunities. Adopting a census approach, the study surveyed all nine operational sawmills using self-administered questionnaires and walkthrough energy audits based on ASHRAE standards. The analysis revealed a significant lack of structured energy management; most facilities do not monitor consumption or adjust to price changes. Technical assessments identified inefficiencies, notably power factors below 0.9 in seven sawmills and the widespread use of inefficient lighting. While total energy consumption decreased between 2021 and 2022, total electricity costs increased, highlighting the financial impact of these inefficiencies and rising tariffs. The study concludes that the industry misses critical opportunities for cost optimization. Recommendations include the installation of power factor correction banks, retrofitting with LED lighting, and implementing employee training programs. These measures are essential for enhancing profitability and ensuring industrial sustainability in Ghana's forestry sector.

Keywords: Audit; Electricity Consumption; Energy Management; Ghana; Sawmill

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Introduction

The sawmill industry in Ghana is central to national economic development but faces persistent challenges in energy management. Many timber companies lack the technical management know-how to process waste, leaving shavings, sawdust and branches underutilized (Takase et al., 2023). Energy management practices such as systematic economic analyses and tracking of energy use remain limited in Ghana (Sapri et al., 2016), even though effective energy management can substantially reduce electricity costs for industrial and commercial institutions (Trianni et al., 2019).

Energy is fundamental to national growth and long-term sustainability, and this requires secure, affordable and environmentally responsible supply and use (Guevara et al., 2017; World Energy Council, 2010). Yet many countries still struggle with growing demand, fossil fuel depletion and rising greenhouse gas emissions (Fu et al., 2021; Roser, 2020). Energy efficiency, understood as achieving the same level of service with less energy, remains one of the most cost-effective strategies for addressing these challenges (Stenqvist, Nilsson, 2012; Weckmann et al., 2017).

Energy management, broadly defined as the wise and systematic use of energy, spans both supply-side and demand-side interventions (Husain et al., 2018; Thumann, Mehta, 2020). It reduces costs by optimizing existing systems and embedding efficiency into daily operations (Buckley, 2020; Kahlenborn et al., 2012). The benefits documented in industrialized and emerging economies include reduced fuel expenditure while avoiding investment in new generation capacity, as well as improved air quality, competitiveness and social equity (Johansson, 2015; Arthur et al., 2023a; Arthur et al., 2023b). Globally, energy management and efficiency improvements have yielded multi-trillion-dollar savings while enhancing energy security and lowering emissions (Gielen et al., 2019; Worrell et al., 2009; IEA, 2015a).

In Ghana, demand-side initiatives have produced notable gains. The distribution of approximately six million compact fluorescent lamps (CFLs) and the rebate and exchange scheme for inefficient refrigerators have reduced peak-load electricity consumption, and its associated costs and emissions (Energy Commission, 2015). The timber industry forms part of this broader national effort, both as a major electricity consumer and as a potential contributor to biomass-based energy solutions (Agyarko, 2016).

The sawmilling industry expanded markedly in the 1980s and was subsequently regulated through the Trees and Timber (Chainsaw Operations) Regulation of 1991 to address unsustainable harvesting (Lähtinen et al., 2014; Marfo, 2010). In many developing countries, chainsaw operations and sawmilling contribute substantially to GDP, employment, and private sector development (Vanzetti et al., 2021). Experiences from countries such as Norway demonstrate that dedicated energy management teams in sawmilling can significantly reduce energy use in production processes, though barriers such as high investment costs and constrained internal resources remain (Olsson, 2020).

Ghana's economy has been constrained by power supply challenges, most notably during the "Dumsor" crisis around 2016, characterized by capacity shortages, rising demand and poor infrastructure (Fridy, Myers, 2019). Despite stronger investor interest, industries such as sawmilling still face an inadequate, unreliable power supply (Arthur, Locher, 2022; Han et al., 2021). These conditions heighten the importance of energy management, both to control costs and to mitigate the operational risks of power disruptions.

Large industries often have the capacity to absorb high electricity bills and consequently pay limited attention to efficiency, despite evidence that annual electricity expenditure could fund robust energy management programmes (Gyamfi et al., 2013). Many sawmilling companies are unaware of the potential financial benefits of systematic energy management. Addressing this gap requires targeted audits, promotion of energy-efficient technologies, and the institutionalization of basic good practices such as scheduled maintenance and routine energy audits (Nketiah et al., 2001).

Small and medium-sized enterprises (SMEs), including sawmills, account for a significant portion of energy demand – estimated at around 13% – with a technical saving potential of roughly 30% (Chowdhury et al., 2018; IEA, 2015b; Johnson et al., 2019).

Sawmilling is particularly important in Ghana's rural economy, providing substantial employment and generating tax revenues and other local benefits (Kerrett, Wit, 2009). However, empirical research on energy management in Ghanaian sawmills remains limited, and many facilities operate with outdated equipment and inefficient practices.

This study therefore examines energy consumption and management practices in sawmills in the Sunyani Municipality, with the aim of identifying practical efficiency opportunities while informing both industry management and policy. Specifically, it evaluates electricity consumption in selected sawmills, assesses their contributions and constraints in relation to enhanced energy management, and conducts walkthrough energy audits to identify cost-effective energy-saving opportunities in the sawmilling industry.

Literature review

Sawmilling contributes significantly to Ghana's economic development through taxes, employment and local services, and improvements in energy efficiency can amplify these benefits by lowering operating costs and enhancing competitiveness (Chen et al., 2021; Kerrett, Wit, 2009). Energy management encompasses both supply-side measures (such as fuel choice and generation technology) and demand-side actions aimed at optimizing energy use and reducing unit energy costs (Doty, Turner, 2004; Jimenez et al., 2022). In industrial settings, demand-side management is particularly important, involving technologies and practices such as efficient electric motors and HVAC systems, process monitoring and systematic maintenance. As summarized in Table 1, the principal dimensions of industrial energy management typically include technological, operational, behavioural and policy-related factors that jointly influence total energy consumption.

Table 1. Heat and electricity consumption in lumber processing

	Electricity [kWh/m^3 lumber]	Heat [kWh/m^3 lumber]
Barking	4	0
Sawing	23	10
Sorting	2	5
Drying	31	299
Dry handling	4	5
Grinding	13	5

Source: Anderson, Westerlund, 2011

From an environmental perspective, energy management seeks to reduce the ecological footprint of energy consumption by integrating renewable energy sources (for example, solar, wind and biomass), lowering greenhouse gas emissions, and supporting sustainable building and process design (Owusu, Asumadu-Sarkodie, 2016; Song et al., 2020). Socially, it can address energy poverty by improving access to affordable, reliable energy and encouraging conservation behaviours among households and firms. Legally and institutionally, energy management must align with regulations and efficiency standards, which in Ghana include national energy efficiency action plans, appliance standards and labelling schemes (Della Valle, Czako, 2007; Ministry of Power, 2015).

Resource efficiency aims at the responsible use of materials, energy, water, and other natural resources to reduce environmental impacts and ensure long-term security of supply. In the context of sawmills, energy resource efficiency is closely tied to the adoption of efficient technologies, such as LED lighting, high-efficiency motors, and improved kiln systems, which reduce electricity and fuel consumption (Johansson, 2015). It also involves the productive use of by-products such as sawdust and wood chips as biomass fuels rather than waste.

Regular energy audits are a core instrument for achieving energy resource efficiency. They provide a systematic assessment of energy flows, identify areas of waste and support the development of targeted interventions (Lisauskas et al., 2022). The present study's focus on walkthrough audits in Sunyani sawmills fits within this broader approach, aiming to identify low-cost and investment-grade opportunities for efficiency improvements and emissions reduction.

Energy efficiency can be understood as delivering the same service or output with less energy input, thereby reducing both costs and environmental burdens. At the industrial level, the International Energy Agency emphasizes that improved energy efficiency allows firms to increase production and value added while using less energy per unit of output (IEA, 2015a; Javied et al., 2015). In practice, this involves technological measures (such as high-efficiency motors, variable-speed drives and advanced controls), behavioural measures (for example, switching off idle equipment), and policy instruments (standards, incentives and information programmes).

Behavioural and organizational changes, including improved operational discipline and awareness campaigns, can deliver substantial savings at relatively low cost (Vasseur et al., 2019). Policy frameworks can reinforce these efforts through minimum performance standards, energy labels and financial incentives for efficient equipment and retrofits (Johansson et al., 2019). For the sawmill industry, energy efficiency means using less electricity and heat for debarking, sawing, drying and material handling, primarily through more efficient equipment, better process control, and the recovery and use of waste heat and biomass.

Sawmills convert roundwood into lumber through a sequence of energy-intensive operations including timber handling, debarking, sawing, sorting, drying and packaging (Nketiah et al., 2001). These processes generate substantial by-products – bark, sawdust, and wood chips – typically amounting to over half of the dry mass of incoming logs, with less than half ending up as marketable lumber (Anderson, Westerlund, 2011). Heat and electricity are the dominant energy forms used in sawmills, with drying representing the largest single energy consumer.

Empirical studies show that drying can account for the vast majority of thermal energy use in sawmills, often more than four-fifths of total heat consumption per unit of lumber, while debarking, sawing, sorting and material handling require smaller but still significant amounts of electricity and heat (Anderson, Westerlund, 2011). Basic descriptive statistics for typical lumber processing indicate that heat use is both higher and more variable than electricity use, reflecting differences in kiln technology, operating practices and product requirements. The high energy intensity and variability of drying operations highlight them as priority targets for efficiency investments, such as improved kiln design, better process control and optimized schedules.

Many existing drying systems were designed when biomass and energy prices were lower. In contemporary conditions of rising biomass and electricity prices, modernization of drying facilities and better integration of heat recovery systems can be financially attractive. At the same time, electricity-driven processes – material handling, sawing, grinding, lighting and ventilation – offer additional opportunities for efficiency through modern motors, controls and lighting retrofits (Anderson, Westerlund, 2011).

Electric motors are central to sawmill operations, powering saws, conveyors, planers, moulders and other material-handling equipment. Their efficiency and operating patterns therefore have a major influence on total electricity consumption and cost. Power factor correction, often achieved through capacitor banks, is another key element of sawmill energy management because inductive motor loads can lead to low power factors and associated utility penalties. Power factor correction devices and harmonic filters help improve power quality and reduce reactive power demand, thereby lowering apparent power and related charges (Lotsu et al., 2019).

In many sawmills, motors are left running when not in active use and lighting is kept on regardless of daylight availability, largely due to operational habits and concerns over equipment wear from frequent starts. Evidence from Ghana suggests that firms often repair rather than replace inefficient motors and that awareness of the economic benefits of energy-efficient motors and variable-speed drives remains low (Nketiah et al., 2001). Limited availability of high-efficiency equipment and specialized service providers further constrain adoption locally.

Ghana's sawmill industry is both energy-intensive and strategically important, especially in the context of government policies encouraging value addition to wood products prior to export. While many facilities use processing residues as biomass for heat, opportunities remain to improve the efficiency with which this biomass and purchased electricity are used. Upgrading to efficient motors, kilns and lighting; implementing automation and real-time monitoring; and optimizing process flows can all reduce energy consumption per unit of output (Chowdhury et al., 2018; Green, 2015; Yue et al., 2021).

At the policy level, the Economic Community of West African States (ECOWAS) has promoted regional energy efficiency initiatives, and Ghana has adopted national policies and regulations in line with these frameworks, including appliance standards and labelling, fiscal incentives and demand-side management programmes (Energy Commission, 2015; Ministry of Power, 2015). Programmes such as the distribution of efficient lamps and refrigerator replacement schemes have produced significant peak load reductions and cumulative energy savings, demonstrating that relatively simple measures can yield large system-wide benefits. The installation of capacitor banks in public institutions, which produced measurable reductions in apparent power demand, illustrates the potential for power factor correction measures in industrial sectors, including sawmills (Lotsu et al., 2019).

Within sawmills, improving energy management requires a combination of technological, organizational and behavioural interventions. Investments in efficient machinery and automation systems can optimize energy use in real time and reduce waste, while energy monitoring systems enable managers to track consumption, identify anomalies and evaluate the impact of interventions (Taghizadeh-Hesary et al., 2021). Employee engagement and training can foster an internal culture of energy conservation and encourage the identification of operational inefficiencies (Nkansah et al., 2022). Finally, the increased adoption of biomass-based energy systems in Ghanaian sawmills, using waste wood to generate heat and electricity, offers a pathway to reduce reliance on fossil fuels, cut greenhouse gas emissions, and enhance local energy self-reliance (Mawusi et al., 2023).

Collectively, the literature suggests that substantial cost-effective potential remains untapped in the sawmill sector, particularly in electricity-intensive operations, drying processes, power factor correction and the systematic use of energy audits and monitoring systems. The present study contributes to this literature by providing empirical evidence on actual energy management practices, demand profiles and saving opportunities in Sunyani Municipality sawmills.

Methods

The research design involved a quantitative survey and a walkthrough energy audit. The survey included a self-administered questionnaire, while the energy audit involved observation, interaction with workers, and access to historical data. The selection of sawmills in the Sunyani Municipality was based on accessibility and operational status. The study adopted a census approach, surveying all nine registered and operational sawmills in the municipality (Verma et al., 2017). For broader context, the Ghana Timber Transparency Portal lists approximately 1,414 registered timber processors nationwide, indicating that the sawmilling sector is a vast component of the national economy (Ghana Timber Transparency Portal, 2025). This census approach ensures 100% representation of the study area, though generalization to the national level is limited given the scale of the broader industry. The sawmills included were Prinsab, Adabokrom, Gyamase, Akrodie, Nobekaw, Adjoa Forjour, Chief, Oti Yeboah and Magazine.

Data gathered from the questionnaires and audits were analyzed using Microsoft Excel and SPSS Version 26. Descriptive statistics, including frequencies, means and standard deviations, were calculated to profile energy consumption patterns. Trend analysis was conducted to compare electricity costs and consumption rates between the years 2021 and 2022.

An energy audit is crucial for uncovering energy-saving opportunities in energy-intensive industries like sawmills. The study conducted an energy audit on all sawmills in the study area to assess their energy performance, identify high-consumption areas, and propose energy-saving measures. The audit aimed not only to cut costs but also to reduce carbon emissions and enhance sustainability. This section details the audit process, data collection and findings, forming the basis for recommendations to improve energy efficiency in the sawmill industries. Energy auditing, employing the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard, is utilized to pinpoint inefficiencies in sawmilling appliances. ASHRAE defines energy audits as processes where engineering service providers identify and recommend efficiency opportunities. The walkthrough energy audit targets lighting and motors, utilizing a power analyzer to assess motor power factors. The objective is to identify and recommend energy-saving opportunities to sawmill managers, emphasizing simplicity and familiarization with the ASHRAE standard. The research focused on energy-consuming appliances in the nine identified sawmills, utilizing a walkthrough energy audit. Interactions with sawmill managers guided the audit's scope, emphasizing lighting and motor operations, with considerations for bulb and motor capacities. Power factor assessments were conducted to evaluate energy utilization.

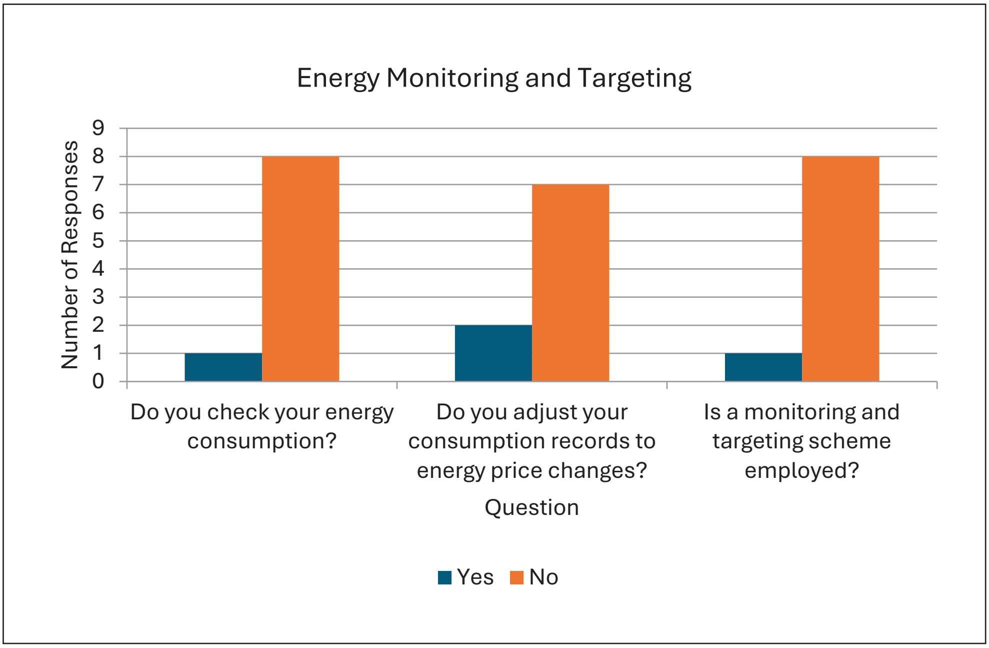
The researcher employed ASHRAE guidelines for standardized energy audits, ensuring a consistent methodology. ASHRAE was a useful standard used because of its simplicity and familiarization while it and other entities have defined energy audits as processes in which engineering service providers identify and recommend efficiency opportunities to clients. Rigorous quality control measures include double-checking data accuracy, performing validation checks, and correcting errors to enhance the reliability of collected data from audits and questionnaires.

Ethical considerations were prioritized to safeguard participants and research integrity. Informed consent was secured from all sawmill industries, respecting their autonomy. Confidentiality and anonymity were rigorously maintained, treating collected data confidentially and anonymizing sawmill identities to protect privacy. Aggregated data presentation ensured participant identity remained undisclosed. These ethical practices upheld responsible and respectful research conduct, prioritizing the well-being and rights of the participants.

Results

Energy Consumption Patterns amongst Sawmill Industries. The questionnaire responses (Figure 1) highlight key aspects of sawmill energy consumption patterns.

Figure 1. Responses to Questions



Source: fieldwork, 2022

Most respondents (7 out of 9) do not monitor their energy consumption or adjust to price changes. Additionally, 8 out of 9 sawmills do not implement monitoring or target schemes. Table 2 reveals varying power purchase frequencies, with one sawmill buying power dependent on production levels. Overall, the findings suggest a lack of systematic monitoring and management of energy consumption among sawmill operators, indicating potential areas for improvement.

Table 2. Number of times in a month respondents buy power

SAWMILL NAME	Number of times you purchase power
PRINSAB SAWMILL	2 times
ADABOKROM SAWMILL	Uncountable
SAWMILL GYAMASE	3 times
SAWMILL AKRODIE	3 times
NOBEKAW SAWMILL	2 times
ADJOA FORJOUR SAWMILL	1 time
CHIEF SAWMILL	1 time
OTI YEBOAH	2 times
MAGAZINE SAWMILL	3 times

Source: fieldwork, 2022

Table 2 details the frequency of power purchases by different sawmills within a month, revealing varied energy consumption patterns across the industry. Some sawmills purchase power multiple times monthly, indicating high energy usage or inefficient energy management, while others, with fewer purchases, may indicate lower consumption or better efficiency. This variance underscores the need for tailored energy efficiency strategies within the sawmill sector to optimize power usage and reduce costs.

Energy Saving Opportunities. All sawmills rely on electricity as their primary energy source. The energy audits assessed electricity consumption and costs for 2021 and 2022, with results summarized in Table 3.

Table 3. Electricity Consumption and Cost Analysis (2021–2022)

SAWMILL NAME	2021		2022	
	Annual cost of electricity (GHC)	Electricity consumption (kWh)	Annual cost of electricity (GHC)	Electricity consumption (kWh)
PRINSAB SAWMILL	20,000.00	9,302.33	15,000.00	4,687.50
ADABOKROM SAWMILL	10,000.00	4,651.16	7,000.00	2,187.50
SAWMILL GYAMASE	13,500.00	6,279.07	16,500.00	5,156.25
SAWMILL AKRODIE	9,800.00	4,558.14	9,800.00	3,062.50
NOBEKAW SAWMILL	17,000.00	7,906.98	21,000.00	6,562.50
ADJOA FORJOUR SAWMILL	10,000.00	4,651.16	16,000.00	5,000.00
CHIEF SAWMILL	12,000.00	5,581.40	16,250.00	5,078.13
OTI YEBOAH	56,000.00	26,046.51	62,000.00	19,375.00
MAGAZINE SAWMILL	9,600.00	4,465.12	11,200.00	3,500.00
Total	157,900.00	73,441.86	174,750.00	54,609.38

Source: fieldwork, 2022

While total consumption decreased by 25.6% from 2021 to 2022, the total cost increased by 10.6%. This indicates a significant rise in the average unit cost of electricity or the application of penal rates for poor power factors, highlighting a deterioration in cost efficiency despite lower volume usage.

The research team focused on lighting and electric motors during the walk-through survey, specifically examining power factors. Table 4 reveals that two out of nine sawmills in Sunyani had a power factor exceeding 0.9, while the remaining seven had power factors below 0.9.

Table 4. Sawmills and the power factor range

SAWMILL NAME	PF
Prinsab Sawmill	< 0.9
Adabokrom sawmill	< 0.9
Sawmill Gyamase	< 0.9
Sawmill Akrodie	< 0.9
Nobekaw Sawmill	< 0.9
Adjoa Forjour Sawmill	> 0.9
Chief Sawmill	< 0.9
Oti Yeboah	> 0.9
Magazine Sawmill	< 0.9

Source: fieldwork, 2022

This suggests inefficient motor usage or a lack of power factor correction equipment, such as capacitor banks, in the sawmills.

Table 3 provides a detailed comparison of energy consumption and costs for sawmills in Sunyani Municipality across 2021 and 2022. It shows varied energy use, with PRINSAB SAWMILL reducing its electricity cost from GHC 20,000 to GHC 15,000 and consumption from 9,302.33 kWh to 4,687.50 kWh. In contrast, NOBEKAW SAWMILL's cost rose from GHC 17,000 to GHC 21,000, and consumption decreased from 7,906.98 kWh to 6,562.50 kWh. OTI YEBOAH saw the highest increase in cost from GHC 56,000 to GHC 62,000, although its consumption decreased from 26,046.51 kWh to 19,375 kWh. Overall, the total annual electricity cost for all sawmills combined increased from GHC 157,900 to GHC 174,750, despite a decrease in total consumption from 73,441.86 kWh to 54,609.38 kWh, indicating a shift towards higher electricity rates or more efficient energy usage in some areas while highlighting the critical need for enhanced energy management strategies across the sector.

Notably, OTI YEBOAH's consumption dramatically exceeds all others, indicating potential inefficiency or larger-scale operations. Despite some sawmills reducing consumption, the total electricity cost and consumption rose, highlighting an urgent need for industry-wide energy efficiency improvements and sustainable practices to mitigate rising operational costs.

Table 4 illustrates electricity consumption and costs for sawmills in Sunyani Municipality for 2021 and 2022. For example, as noted above OTI YEBOAH's costs rose from GHC 56,000 to GHC 62,000, despite a reduction in consumption from 26,046.51 kWh to 19,375 kWh. Overall, despite varied individual changes, the total annual cost increased from GHC 157,900 to GHC 174,750, reflecting broader industry trends and the need for efficiency improvements. The walkthrough survey revealed that motors were often left running when not in use, and lights were kept on during the daytime. Observation also indicated that many sawmills were using less efficient bulbs. The data on sawmills' electricity usage reveals a crucial trend of increasing total annual costs despite varied individual consumption changes, such as OTI YEBOAH's significant reduction in kWh usage. This indicates rising electricity prices or increased operational scales, emphasizing the pressing need for energy efficiency measures and cost management strategies to mitigate their financial impact on the sawmill industry in Sunyani Municipality.

Discussion

The questionnaire results reveal a notable lack of attention and concern for energy consumption and efficiency in most surveyed sawmills. This attitude suggests that these businesses possess sufficient financial resources to cover utility bills, thereby minimizing immediate worry about electricity costs. Consequently, large companies often neglect energy management due to their ample resources to cover energy expenses. The survey further revealed that the majority of sawmill managers do not monitor their energy consumption or adjust records in response to energy price changes. Additionally, most sawmills lack monitoring and target schemes, indicating a deficiency in structured energy management practices. This oversight suggests a potential lack of awareness and commitment to energy efficiency, hindering the identification of inefficiencies and the implementation of cost-saving measures. Establishing regular monitoring, adjusting consumption based on energy price changes, and implementing monitoring and target schemes are crucial energy management practices to enhance efficiency and foster a culture of energy conservation in the sawmill industry.

The situation in Sunyani mirrors challenges in similar developing economies. For instance, sawmills in Nigeria and Malaysia have reported comparable struggles with rising energy costs and a lack of modern energy management systems. However, unlike the Malaysian timber sector, which has seen higher adoption of biomass cogeneration, the sawmills in this study rely almost exclusively on grid electricity, exacerbating their vulnerability to tariff hikes. Insights into power purchasing behavior reveal that three out of nine sawmills buy power three times a month, while one sawmill adapts its purchasing frequency to production levels. This suggests a correlation between energy consumption and production output. Although there is a degree of awareness, sawmill managers must analyze production patterns thoroughly. Implementing forecasting methods can help estimate energy needs based on production forecasts, optimizing cost-efficiency and minimizing energy waste.

The sawmill industry's energy management can significantly benefit from adopting energy-efficient technologies in operations. Upgrading machinery to energy-efficient models reduces consumption and enhances operational efficiency. Such investments lead to substantial energy savings and increased productivity in manufacturing industry. Furthermore, automation and control systems play a crucial role in optimizing energy consumption. These systems monitor and adjust machinery settings, optimize production schedules, and minimize idle time. Utilizing automation and control systems allows sawmills to enhance their energy management practices, achieving more efficient energy usage.

Deepening the economic analysis reveals significant potential for savings. Given that seven out of nine sawmills operate with a Power Factor (PF) below 0.9, they are likely incurring surcharges from the utility provider. By installing capacitor banks to correct the PF to above 0.95, these sawmills could eliminate reactive power penalties. Furthermore, replacing the observed inefficient lighting with LED alternatives could reduce the lighting load by approximately 50–60%. Based on the 2022 total electricity cost, even a conservative efficiency gain through these low-cost interventions would yield substantial industry-wide annual savings for the municipality. Addressing power factor issues is crucial for optimizing energy consumption. Installing power factor correction equipment, like capacitor banks, improves the power factor and reduces reactive power consumption, enhancing energy efficiency and overall electrical system performance.

Referring to national policies, specifically the "Electricity Demand Management Fund," and labeling standards, it is evident that these mechanisms are not effectively reaching the sawmill level. The continued use of inefficient motors and low power factors suggests a gap between the Energy Commission's regulatory framework and on-the-ground industrial compliance. The lack of enforcement of Legislative Instrument (LI) 1815 in this sector represents a significant barrier to industrial sustainability. Energy monitoring systems enable sawmills to track and analyze energy consumption, identifying inefficiencies needing optimization. Real-time data analysis offers insights and uncovers opportunities for energy savings, leading to improved efficiency and operational performance. Additionally, employee engagement and training in energy conservation significantly improve sawmill energy management. Educating and involving employees fosters an energy-efficient culture, empowering staff to identify and participate in conservation initiatives.

The results regarding energy-saving opportunities show that most sawmills exhibited a decline in annual electricity consumption between 2021 and 2022, yet the total annual cost increased. This highlights a critical trend of increasing operational costs despite varied individual consumption changes. Specifically, the total annual electricity cost for all sawmills combined increased from GHC 157,900 to GHC 174,750, despite a decrease in total consumption. This discrepancy indicates rising electricity prices or the application of penal rates for poor power factors, emphasizing the pressing need for energy efficiency measures and cost management strategies to mitigate the financial impact on the sawmill industry in Sunyani Municipality.

Conclusions

The study focused on evaluating energy consumption in Sunyani's sawmill industries, aiming to understand current energy practices and propose energy-efficient improvements. This involved analyzing questionnaire responses and conducting a walkthrough energy survey of all operational sawmills in the municipality. Most sawmill managers lacked active monitoring of energy consumption, revealing a deficiency in energy management awareness. This emphasizes the necessity for heightened education and awareness regarding the significance of monitoring and optimizing energy usage. The sawmills' limited response to energy price changes implies a missed opportunity for cost optimization and energy efficiency. Moreover, the absence of monitoring and target schemes among the majority indicates a lack of structured energy management approaches.

The study suggests a need for a more strategic and proactive approach to energy procurement by sawmills. It identifies areas for improvement, including the use of energy-efficient technologies, implementation of automation and control systems, adoption of power factor correction measures, adherence to energy monitoring and data analysis, and employee engagement through training to enhance energy management practices. The walkthrough survey revealed critical issues such as electric motors with power factors less than 0.9 and inefficient practices such as leaving motors running when not in use and using inefficient lighting. The recommendations derived from these findings are for sawmills to implement energy monitoring systems for tracking consumption patterns, adapt to energy price changes, and establish monitoring and target schemes. Raising awareness among sawmill employees through training and campaigns is likewise crucial.

Furthermore, conducting frequent energy audits, integrating energy management into daily operations, and setting reduction targets are advised. Specifically, adopting power factor correction devices to enhance system efficiency and engaging employees in energy management through training sessions are key strategies. Operational improvements should be supported by policy enforcement, where the Energy Commission extends its monitoring of efficiency standards specifically to the timber processing sector. These comprehensive measures aim to improve energy efficiency, reduce costs and foster a culture of energy conservation within the sawmill industry. While this study employed a census approach to ensure full representation of the Sunyani Municipality, the sample size was limited to this specific geographic area. Consequently, the findings may not be fully generalizable to the national sawmill sector without further broad-scale research. Future research could enhance the study's breadth by including a larger, more diverse sample of sawmills for a more comprehensive understanding of energy management practices across Ghana.

Declarations

Statement on Conflict of Interests/Competing Interests

The authors declare that there are no conflict of interest issues related to this manuscript.

Statement of Ethic approval

The Ethics protocol was approved by the Ethics Review Board (IRB) of the Kwame Nkrumah University of Science and Technology (KNUST), Ghana following regulations guiding the use of human participants in research.

Consent to participate

Informed consent was obtained from all individual participants included in the study. Participation was voluntary and assurance of confidentiality was given to respondents before they participated in the research. Personal information as well as information that could identify a particular respondent was not sought from the respondents.

Consent to publish

The authors affirm that human research participants provided informed consent for the publication of the research work. This also related to the fact that personal information or information that could identify a participant was not sought from respondents. Meanwhile, the authors are responsible for the correctness of the statements provided in the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request

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All authors agreed to all the content of the manuscript before it was submitted for consideration.

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