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A comprehensive study on electricity utilization and CO_2 emissions in Sami Laris Swalayan, Cilacap, Indonesia

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ABSTRACT

In today's world, with an increased focus on environmental awareness and sustainability, mitigating carbon footprint has emerged as a crucial goal for businesses across various sectors, including supermarket chains. This research centers on Sami Laris Swalayan, a prominent and widely recognized supermarket chain, to comprehensively analyze its electricity utilization patterns and the corresponding carbon dioxide (CO_2) emissions. By delving into electricity utilization data spanning a specific period, this study identifies peak demand periods, explores energy-efficient opportunities, and assesses the potential for integrating renewable energy sources. The research underscores the significance of reducing CO_2 emissions, advocating sustainable energy practices within the supermarket chain, contributing to environmental conservation efforts, and fostering a culture of responsible energy management. The investigation begins with a thorough analysis of Sami Laris Swalayan's electricity utilization, seeking to understand the varying trends and patterns in energy consumption. The data above shows the fluctuating electricity consumption of the company, with the highest figure recorded in April, reaching 26,965 kWh. The high electricity usage is attributed to the total operational hours from 09:00 to 21:00 and the addition of other facilities such as the accessory room, bakery outlet, and coffee outlet. In contrast, the lowest consumption was observed in February, with 23,796 kWh, which was influenced by the implementation of Large-Scale Social Restrictions (PSBB) at the end of January 2021. During this period, the operational hours were shortened from 09:00 to 19:00, leading to a decrease in electricity consumption the following month.

ABSTRAK

Dalam era modern ini, dengan fokus yang semakin meningkat pada kesadaran lingkungan dan keberlanjutan, mengurangi jejak karbon telah menjadi tujuan krusial bagi bisnis di berbagai sektor, termasuk rantai supermarket. Penelitian ini berfokus pada Sami Laris Swalayan, sebuah rantai supermarket yang terkemuka dan dikenal luas, untuk melakukan analisis komprehensif terhadap pola penggunaan listrik dan emisi karbon dioksida (CO_2) yang terkait. Dengan menggali data penggunaan listrik selama periode waktu tertentu, penelitian ini bertujuan untuk mengidentifikasi periode permintaan puncak, mengeksplorasi peluang hemat energi, dan menilai potensi integrasi sumber energi terbarukan. Penelitian ini menekankan pentingnya mengurangi emisi CO_2 dan mendorong praktik energi berkelanjutan di dalam rantai supermarket, sehingga ikut berkontribusi pada upaya konservasi lingkungan dan menumbuhkan budaya pengelolaan energi yang bertanggung jawab. Penelitian ini dimulai dengan analisis mendalam terhadap penggunaan listrik Sami Laris Swalayan, dengan tujuan untuk memahami tren dan pola variasi dalam konsumsi energi. Data di atas menunjukkan konsumsi listrik perusahaan yang fluktuatif, dengan angka tertinggi tercatat pada bulan April, mencapai 26.965 kWh. Tingginya penggunaan listrik disebabkan oleh total jam operasional dari pukul 09:00 hingga 21:00 dan penambahan fasilitas lain seperti ruang aksesoris, outlet roti, dan outlet kopi. Sebaliknya, konsumsi terendah diamati pada bulan Februari, sebesar 23.796 kWh, yang dipengaruhi oleh penerapan Pembatasan Sosial Berskala Besar (PSBB) pada akhir Januari 2021. Selama periode ini, jam operasional dipersingkat dari pukul 09:00 hingga 19:00, mengakibatkan penurunan konsumsi listrik pada bulan berikutnya.

Keywords: *electricity utilization, carbon footprint, CO_2 emissions, sustainable energy practices, supermarket chains*

INTRODUCTION

Recently, there has been a growing awareness and emphasis on environmental sustainability, prompting a heightened concern about the impact of electricity consumption on greenhouse gas emissions (Snigdha et al 2023, Uddin et al 2022, Noviarini et al., 2022). Supermarket chains, as major electricity consumers, have a significant role to play in addressing this issue (Valaskova et al., 2021). Among them, Sami Laris Swalayan stands out as a prominent player, necessitating a thorough investigation into its energy consumption patterns and subsequent carbon dioxide (CO_2) emissions. The commercial sector, of which supermarket chains are a pivotal component, accounts for a considerable share of electricity usage (Yuliani et al., 2023). Utilizing energy-intensive equipment, such as refrigeration systems, lighting, and air conditioning, significantly releases CO_2 emissions within these establishments (Suamir & Tassou, 2013). Understanding the electricity

consumption patterns and emission factors specific to supermarket operations is imperative to address this issue effectively. Armed with this knowledge, the research aims to devise efficient and targeted strategies to mitigate the environmental footprint of supermarket chains. By examining the electricity utilization and CO_2 emissions within Sami Laris Swalayan, this research sheds light on its impact on the environment and its potential contributions to climate change. The findings are expected to provide valuable insights into the energy consumption patterns unique to supermarkets and the associated CO_2 emissions. With this information, stakeholders can adopt sustainable energy practices to minimize the ecological consequences and foster a more environmentally responsible approach to energy management within Sami Laris Swalayan.

The significance of this research lies in its potential to prompt meaningful change in energy consumption practices within the supermarket chain industry. Analyzing the electricity utilization data and the subsequent CO_2 emissions of Sami Laris Swalayan, researchers can pinpoint areas for improvement and propose practical solutions to reduce its environmental impact. Furthermore, the research outcomes can serve as a benchmark for other supermarket chains, encouraging adopting sustainable energy practices across the sector. In this research, an in-depth analysis of the electricity utilization patterns in Sami Laris Swalayan will be conducted, aiming to gain a comprehensive understanding of the supermarket chain's energy consumption behaviors.

Moreover, the research will explore energy-efficient opportunities within Sami Laris Swalayan. Scrutinizing electricity utilization data, the study will pinpoint areas where energy-saving measures can be implemented effectively. These could include optimizing lighting systems, HVAC (heating, ventilation, and air conditioning) units, refrigeration systems, and other energy-intensive equipment used within the supermarket chain. Identifying energy-efficient opportunities will not only lead to cost savings for the business but also contribute to reducing the overall CO_2 emissions associated with electricity consumption Furthermore, the research aims to assess the potential for adopting renewable energy sources within Sami Laris Swalayan. The study will offer valuable recommendations for the supermarket chain to transition towards cleaner and sustainable energy practices by evaluating the feasibility of integrating solar panels, wind turbines, or other renewable energy technologies. The incorporation of renewable energy sources would not only reduce the carbon footprint but also enhance the resilience and long-term sustainability of the business. The primary objective of this research is to emphasize the significance of reducing CO_2 emissions within Sami Laris Swalayan. By quantifying the carbon emissions associated with electricity utilization, the study will create awareness of the environmental impact (Lannelongue et al., 2021l; Lacoste et al., 2019) of the supermarket chain's energy consumption. This will prompt stakeholders to recognize the urgency of adopting sustainable energy practices to minimize their carbon footprint.

METHODS

Data Collection

The research methodology will collect data from Sami Laris Swalayan's, Cilacap, Indonesia (Figure 1) energy records and utility bills to obtain accurate electricity utilization data. Emission factor data will be sourced from reliable environmental agencies and energy providers. By applying the emission factor to electricity utilization, the research will calculate the CO_2 emissions. Using electricity utilization data as secondary data for this research holds significant importance for several reasons. Firstly, electricity utilization data is readily available from utility companies and official records, ensuring easy access and saving valuable time and resources compared to collecting primary data through surveys or monitoring. Secondly, this secondary data can cover a considerable period, providing historical trends and seasonal variations in energy consumption and offering valuable insights into long-term changes.

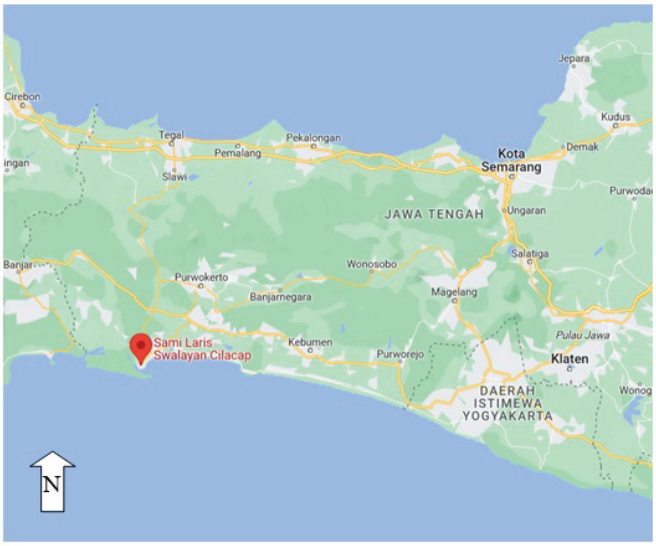

Figure 1. Study site in Sami Laris Swalayan (Google Map 2021)

Moreover, electricity utilization data encompasses various residential, commercial, and industrial sectors, allowing for a comprehensive analysis of electricity consumption patterns across different areas (Noviarini et al., 2022). As the data is derived from metered readings and detailed billing information, its accuracy and precision are ensured, enhancing the reliability of the research findings. Additionally, the large sample size provided by standardized electricity utilization data

allows for statistically significant analysis and a more comprehensive understanding of electricity consumption trends.

LPG Applications in Vehicles

Calculating the carbon footprint in the electricity aspect is based on the average monthly electricity consumption accumulated into the annual electricity consumption. The carbon emissions generated in the energy sector are calculated using the equation based on the Greenhouse Gas (GHG) Inventory and Monitoring and Verification report by the Ministry of Environment and Forestry (2017) (Adinugroho et al., 2019; Noviarini et al., 2022), as follows:

$$\text{GHG Emissions/Absorption} = DA \times FE \quad (1)$$

Where:
DA = data on human or development activities that result in GHG emissions or absorption.
FE = GHG, emission or absorption factor, indicating the amount of emissionst/absorption per unit of activity performed.

The emission factor for the Java-Madura-Bali Interconnection System (Jamali) is crucial to this research because it provides a standardized value representing the amount of carbon dioxide (CO_2) emissions produced per unit of electricity generated (per megawatt-hour, MWh) in that specific electricity system (Table 1). This emission factor is critical in calculating the carbon footprint of electricity consumption in the Sami Laris Swalayan supermarket chain. Furthermore, this emission factor provides a benchmark to compare the environmental performance of different electricity systems or energy sources. It enables researchers, policymakers, and businesses to identify areas where emissions can be reduced and prioritize adopting cleaner and more sustainable energy practices.

Table 1. Emission factor.

System	Emission factor	Unit
Sistem Interkoneksi Jawa-Madura-Bali (Jamali)	0.877	Ton CO_2/MWh

Source: (Dewi et al., 2021)

RESULT AND DISCUSSION

Electricity Utilization

Electricity usage can be quantified by measuring its consumption and demand. Various factors can affect electricity consumption, including the amount used, typically measured in kilowatt-hours per month. On the other hand, peak demand is expressed in kilowatts (kW) per month or for other equipment within the previous year's range. The data on electricity aspects are obtained from secondary sources held by the company. The specified period for analysis is from January 2021 to April 2021, as electricity usage in previous years was not consistently monitored, leading to incomplete record-keeping. The power capacity of the electricity used is 82,500 watts. Figure 2 illustrates the company's electricity consumption patterns during the mentioned time frame.

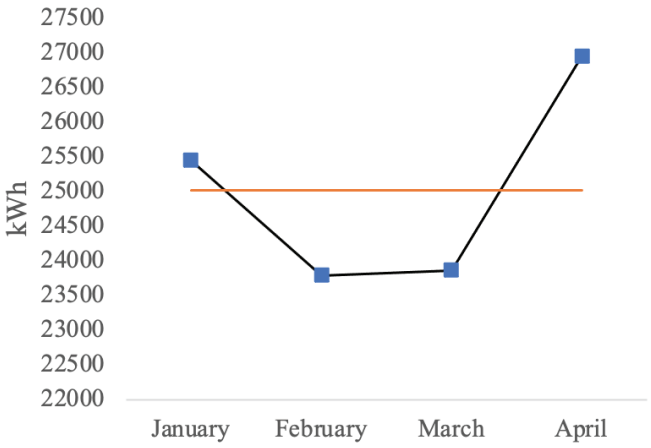

Figure 2. Graph of electricity consumption for January 2021 to April 2021

The data above shows the fluctuating electricity consumption of the company, with the highest figure recorded in April, reaching 26,965 kWh. The high electricity usage is attributed to the total operational hours from 09:00 to 21:00 and the addition of other facilities such as the accessory room, bakery outlet, and coffee outlet. In contrast, the lowest consumption was observed in February, with 23,796 kWh, which was influenced by the implementation of Large-Scale Social Restrictions (PSBB) at the end of January 2021. During this period, the operational hours were shortened from 09:00 to 19:00, leading to a decrease in electricity consumption in the following month.

The data for calculating carbon emissions is based on the highest consumption, which is 26,965 kWh, representing the overall electricity usage. The implementation of PSBB policies directly caused a decrease in demand, including the national electricity needs. Electric energy consumption experienced a decline due to PSBB's restrictions on business and industrial activities (BPTT, 2020). China also experienced a decrease in consumption, along with advancements in renewable technologies, as COVID-19 reduced energy and CO_2 emissions between 1.5% and 2% per year (Razmjoo et al 2021). One of the most noticeable effects of COVID-19 restrictions was the substantial reduction in traffic and industrial activities. With fewer vehicles on the roads and factories operating at reduced capacity or shutting down temporarily (Suhardono et al 2023), emissions from vehicles and industries significantly decreased. During lockdowns, the demand for energy also changed. Commercial

establishments, including supermarkets like Semilaris Swalayan, operated with altered hours and capacity restrictions. Many people worked from home, leading to reduced energy consumption in office buildings and commercial spaces (Tavakoli et al., 2023; Sari et al., 2023b; Septiariva & Suryawan 2023).

Monitoring and understanding electricity consumption patterns and trends is paramount for companies and regions. It enables operational efficiency by optimizing schedules, workforce shifts, and resource allocation based on peak demand periods. Additionally, closely tracking electricity usage allows for better cost management and financial planning, as companies can identify periods of high usage and implement measures to reduce consumption, leading to cost savings. Furthermore, electricity consumption is closely linked to environmental impact and carbon emissions. Analyzing consumption data helps companies adopt more sustainable practices, reducing their carbon footprint. It also ensures compliance with regulations and policies to promote energy efficiency and environmental conservation. For utilities and energy providers, understanding consumption patterns is crucial for infrastructure planning, grid stability, and anticipating future demand. Moreover, electricity consumption is an economic indicator, reflecting changes in industrial activity and overall economic performance. During crises, such as the COVID-19 pandemic, tracking consumption changes aids in developing strategies for managing energy demand and ensuring resilience. In conclusion, monitoring and analyzing electricity consumption data have far-reaching implications for enhancing energy management efficiency, sustainability, and resilience.

Carbon Footprint

Table 2 presents essential information regarding electricity utilization, emission factor, and CO_2 emissions, offering insights into the environmental impact of electricity consumption. The recorded electricity utilization of 26,965 kWh/m reflects the monthly electricity consumed. The emission factor 0.877 indicates that approximately 0.877 kilograms of CO_2 are emitted for every kilowatt-hour of electricity consumed. Consequently, the calculated CO_2 emissions amount to 23,648.305 kg CO_2/m. This data illustrates the direct correlation between electricity consumption and CO_2 emissions, emphasizing the significance of adopting energy-efficient practices and cleaner energy sources to mitigate environmental consequences. A high emission factor suggests a substantial reliance on fossil fuels for electricity generation, underscoring the need for transitioning to renewable energy sources. By prioritizing energy efficiency, promoting renewable energy adoption, and implementing supportive policies and regulations, (Suryawan & Lee, 2023; Suryawan et al., 2023; Mukeshimana et al., 2021; Ngan et al., 2019) we can collectively work towards reducing the environmental impact of electricity consumption and fostering a more sustainable future.

Table 2. Emission from electricity used in Sami Laris.

Electricity utilization (kWh/m)	Emission Factor (kg CO_2/kWh)	Emission (kg CO_2/m)
26965	0,877	23648.305

Sami Laris Swalayan should prioritize energy efficiency initiatives to optimize electricity usage. This may include upgrading lighting systems to energy-efficient LED bulbs, adopting smart energy management systems for HVAC and refrigeration units, and ensuring regular equipment maintenance to improve their energy performance. Sami Laris Swalayan also should be identifying peak demand periods, the supermarket chain can develop load management strategies to distribute electricity usage more evenly throughout the day. This may involve adjusting operational hours, encouraging customers to shop during off-peak hours, or optimizing equipment usage during peak periods. Considering the feasibility of integrating renewable energy sources (Suryawan et al., 2023; Sari et al., 2023a; Suryawan et al., 2022), such as solar panels or wind turbines (Yendaluru et al., 2020; Chauhan & Saini, 2016), can significantly reduce Sami Laris Swalayan's reliance on fossil fuels and lower its overall carbon emissions. The supermarket chain should explore partnerships with renewable energy providers or invest in on-site renewable energy generation.

Sami Laris Swalayan can adopt sustainable procurement policies to source energy-efficient equipment and products with lower carbon footprints. Partnering with suppliers committed to eco-friendly practices can further contribute to reducing the environmental impact (Suryawan & Lee, 2023; Ngan et al., 2019; Sharma et al., 2023) of the supermarket chain's operations. Procuring energy-efficient equipment and products (Hua & Wang 2019; Wang et al., 2019; Sharma, 2022), Sami Laris Swalayan can directly reduce its energy consumption and, consequently, its carbon emissions. This proactive approach aligns with global efforts to combat climate change and demonstrates the supermarket's commitment to environmental responsibility.

CONCLUSION

In conclusion, this comprehensive study on electricity utilization and CO_2 emissions in Sami Laris Swalayan has provided valuable insights into the supermarket chain's energy consumption patterns and environmental impact. The study also highlighted energy-efficient opportunities within Sami Laris Swalayan, showcasing

areas where implementing energy-saving measures could lead to cost savings and reduced CO_2 emissions. This emphasizes the significance of adopting sustainable energy practices to minimize the supermarket chain's carbon footprint and contribute to environmental conservation.

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