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Carbon Footprint Assessment of LPG Gas Usage in Small Industries: A Case Study of Sami Laris Swalayan Shopping Center

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Abstract
This study aims to assess the carbon footprint associated with the consumption of LPG gas in the Sami Laris Swalayan shopping center, focusing on small industries. The research investigates the environmental impact of LPG usage, emphasizing the importance of carbon emissions reduction in the context of sustainable practices. The study quantifies the annual CO_2 emissions resulting from LPG gas consumption through data collection and analysis, highlighting the linear relationship between gas usage and carbon emissions. The findings provide valuable insights for the shopping center to develop mitigation strategies and promote sustainable practices for carbon footprint reduction. In addition, the research contributes to the knowledge on carbon emissions in small industries and emphasizes the need for energy-efficient measures and alternative energy sources to minimize environmental impact.

1. Introduction

Direct emissions, or scope one emission, are essential in carbon footprint assessment and reduction efforts [1], [2]. These emissions refer to releasing greenhouse gases (GHGs) directly from sources owned or controlled by an organization or entity. They typically include emissions from the combustion of fossil fuels, such as LPG, in on-site equipment and vehicles. Direct emissions contribute directly to the accumulation of GHGs in the atmosphere, leading to climate change and its associated environmental impacts. Therefore, by quantifying and reducing direct emissions, organizations can actively contribute to mitigating climate change and minimizing their ecological footprint [3]–[5].

A shopping center typically consumes significant energy for its daily operations [6], including lighting, heating, cooling, and various equipment and facilities. This energy consumption often relies on fossil fuels, which release carbon dioxide (CO_2) when burned, contributing to greenhouse gas emissions and climate change [7], [8]. Assessing and reducing the carbon footprint, the shopping center can mitigate its environmental impact and contribute to global efforts to combat climate change. Cilacap is a part of the global community facing the consequences of climate change, including rising temperatures, changing weather patterns, and increased frequency of extreme weather events. By reducing its carbon footprint, the shopping center can mitigate these effects and promote a more sustainable and resilient future for the local community.

Small industries like shopping centers can contribute to carbon emissions by using LPG in their tenant businesses [9]. LPG, which stands for liquefied petroleum gas, is commonly used as a fuel source for cooking, heating, and other applications in various businesses, including those within shopping centers. When LPG is burned, it releases carbon dioxide (CO_2), a greenhouse gas contributing to climate change. The amount of CO_2 emissions generated depends on the quantity of LPG consumed and the efficiency of the appliances or equipment used. In shopping centers, multiple tenant businesses' collective usage of LPG can result in a significant carbon footprint [9]. For example, each tenant may utilize LPG for cooking in their restaurants or food stalls, contributing to the emission of CO_2 during their daily operations. It's important to note that the carbon emissions from LPG usage can be influenced by factors such as the frequency of gas cylinder replacements, the efficiency of appliances, and the overall energy management practices of the tenant businesses. Therefore, it becomes crucial for shopping centers to assess and manage the carbon emissions associated with LPG usage by implementing energy-efficient measures, encouraging tenants to adopt sustainable practices, and promoting the use of alternative energy sources with lower carbon footprints. By doing so, shopping centers can reduce their environmental impact and contribute to global efforts to mitigate climate change.

This study aims to inventory the carbon footprint generated by the activities of Sami Laris Swalayan shopping center, explicitly focusing on the usage of LPG. By conducting this study, Sami Laris Swalayan can better understand its carbon emissions resulting from LPG usage. This knowledge allows them to assess their environmental impact accurately and identify areas where they can implement measures to reduce their carbon footprint. In addition, by implementing sustainable practices and reducing carbon emissions, the shopping center can contribute to environmental preservation and demonstrate its commitment to sustainability.

2. Methodology

This research was conducted as a case study at Swalayan Sami Laris, a shopping center located in the heart of the city at Jl. Letjend Suprapto No.69 Kandang Macan, Tegalreja, South Cilacap District, Cilacap Regency, Central Java (Figure 1). The research involved conducting interviews with the tenants of the shopping center. During the interview process to gather data on the utilization of LPG from tenants, it is crucial to follow a structured approach to ensure accurate and comprehensive information. Firstly, introduce yourself and explain the purpose of the interview. Make sure to emphasize that their participation is voluntary and that all information provided will be kept confidential and used solely for analysis and improvement purposes.

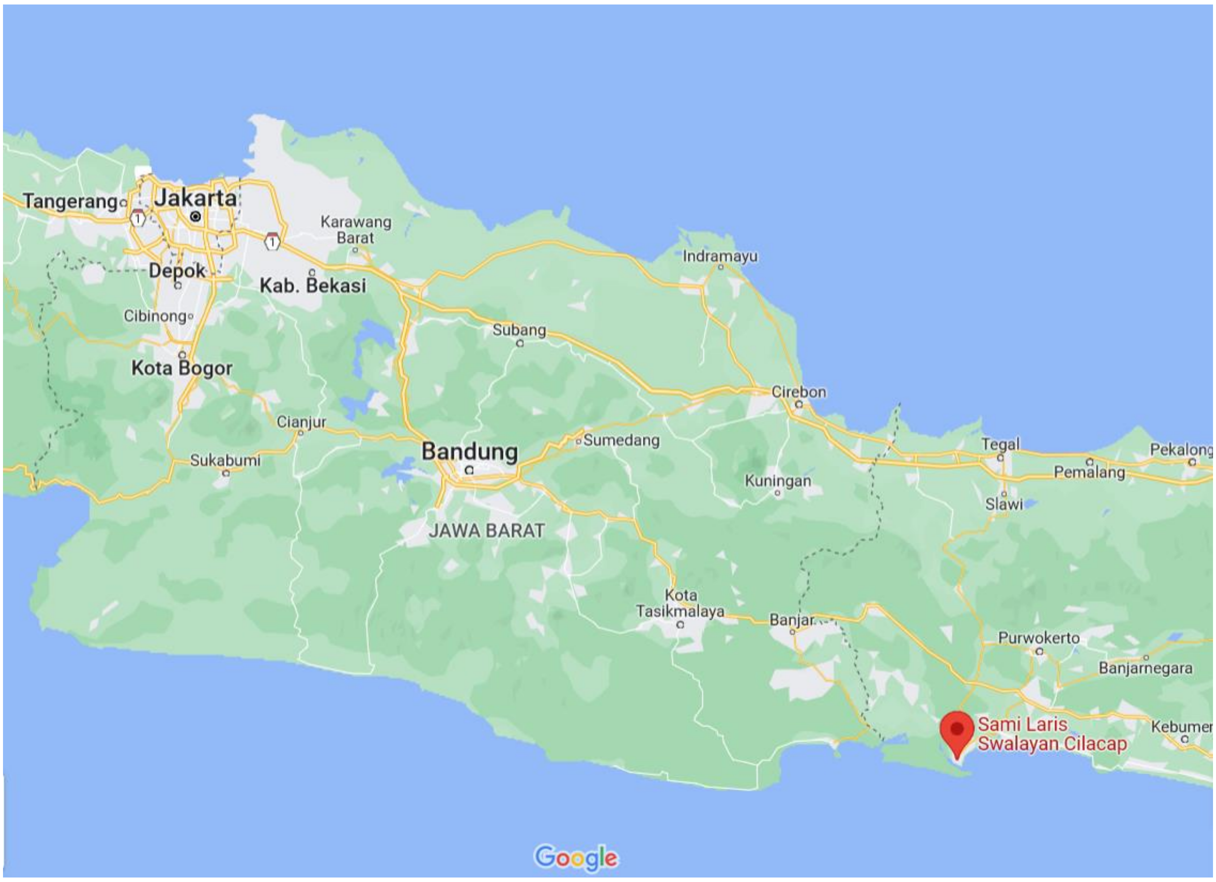

Figure 1. Case Study Location [10]

We prepare a set of interview questions that will help gather the necessary data. Start by asking if they use LPG for their operations and the average number of gas cylinders in a given period. Probe further to understand the average duration of gas cylinder usage before replacement and if there have been any noticeable changes in LPG consumption over time. During the interview, actively listen and ask clarifying questions to understand their responses clearly [8], [11]. We take accurate notes or obtain their consent to record the interview for reference. Finally, express gratitude for their participation and contribution to the data collection process. Offer to address any further questions or concerns they may have. Following this structured approach, you can gather valuable data on LPG utilization from tenants while maintaining professionalism and respect throughout the interview.

The calculation of carbon emissions will be based on the consumption data over one Month, which will then be converted to a yearly basis. The emissions calculation will focus on the food tenants, totaling 8 establishments. The basic calculation model follows the Tier-1 approach, which calculates greenhouse gas emissions based on activity data and emission factors. Activity data refers to the number of activities performed, while emission factors are coefficients indicating the number of emissions per unit of activity. The Tier-1 approach utilizes predetermined (default) emission factors based on the IPCC 2006 GL. The formula applied to calculate carbon emissions is as follows:

$$\text{CO2 Emissions} = \text{Fuel Consumption} \times \text{EF} \times \text{NCV} \qquad (1)$$

Explanation:
CO2 Emissions = Total CO2 Emissions (mass units)
Fuel Consumption = Fuel Consumption (kg/year)
EF = Emission Factor for Fuel (ton CO2)
NCV = Net Calorific Value (energy content) per unit mass or volume of fuel (TJ/ton fuel)

3. Results and discussions

The data obtained regarding the gas aspect is based on interviews conducted with employees of food court tenants. The data collected includes the duration of gas cylinder usage and the type of gas used. In addition, the data collected assumes that the tenants have been established for one year, making the presented data relevant to the emissions generated during that period. A total of 12 tenants were surveyed, consisting of 8 tenants selling food and 4 tenants selling beverages, as shown in Figure 2.

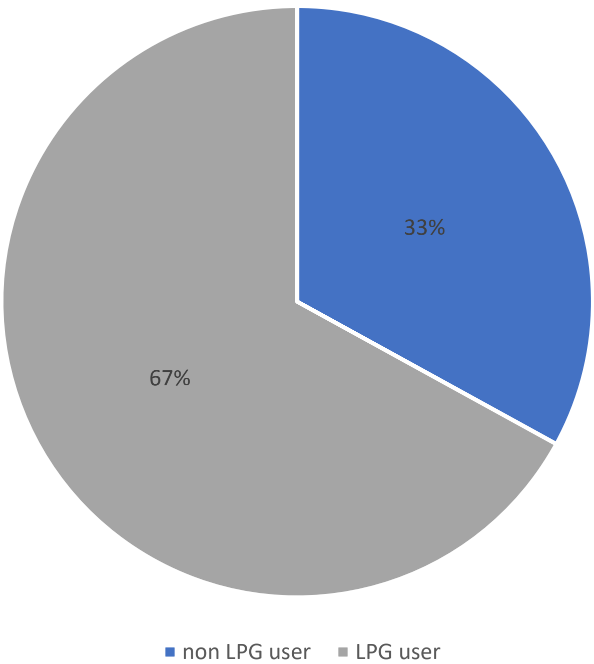

Figure 2. Percentage of LPG Users and Non-LPG Users in the Sami Laris Supermarket Food Court

Table 1. LPG Consumption Data

ID	Type of Gas Cylinder Used (kg)	Frequency of Gas Replacement (per day)	Operational Time in One Month (days)	Total Gas Usage (kg/month)
1	***2***	***3***	***4***	***4 = 1 : 2 x 3***
X1	3	3	30	30
X2	3	4	30	23
X3	3	2	30	45
X4	3	5	30	18
X5	3	3	30	60
X6	3	4	30	23
X7	3	4	30	23
X8	3	4	30	23
X9	0	0	30	0
X10	0	0	30	0
X11	0	0	30	0
X12	0	0	30	0
Total Gas Usage (kg/month)				243

*Assuming one Month is equivalent to 30 days

Table 1 shows that 67% of LPG users consist of 8 food tenants using 3kg LPG gas, while 33% are non-LPG users, comprising 4 beverage tenants not using LPG gas. After determining the number of LPG and non-LPG users, calculations were performed to assess gas consumption based on the frequency of LPG usage by food tenants and then converted into monthly LPG consumption.

Based on Table 1 above, the frequency of gas usage in the beverage category is 0 because beverage tenants do not use gas in their activities. The frequency of LPG usage varies from 3 to 5 days, with the number of gas cylinders used ranging from 1 to 2. The frequency of gas usage for 4 out of 8 food tenants who use 3kg gas cylinders is 4 days. Based on the [12], in 2018, the consumption of LPG reached 7.5 million tons, which was fulfilled by domestic LPG production of 2 million tons (26%) and LPG imports of 5.5 million tons (74%). The successful transition from kerosene to LPG has led to increased LPG consumption. In addition, the subsidized 3 kg LPG consumption has increased due to the participation of many low-income individuals in the government program [13], [14]. On the other hand, gas combustion results in significant nitrogen oxide (NOx) emissions, with approximately 10% of NOx emissions coming from gas usage [15], [16].

The lowest total gas usage within one Month is 6 cylinders for tenant X4, while the highest is 20 cylinders for tenant X5 due to using 2 gas cylinders. The total gas usage per Month for tenant X4 is 18 kg/Month, and for tenant X5, it is 60 kg/month. There is a difference of 42 kg between the highest and lowest gas usage, resulting from variations in the frequency of gas usage (5 days versus 3 days) and the number of cylinders used (1 versus 2). The total monthly gas usage for tenant X4 is 18 kg/month. For tenant X5, the total LPG consumption for one Month is 60 kg/month. The total gas usage for all food tenants in one Month is 243 kg. This gas consumption data will be used to calculate the total CO_2 emissions.

Following equation 1, the calculation of carbon emissions derived from and based on the consumption of LPG gas results in emissions of 8.703 tons of CO_2 per year. It can be observed that there is a linear relationship where the more LPG is used, the higher the resulting CO_2 emissions. As observed in this study, the emission of 8.703 tons of CO_2 per year from the consumption of LPG gas in small industries can be compared to other studies to gain a broader perspective on the emissions generated by LPG usage. It is important to note that emissions can vary depending on various factors, such as the scale of the industry, energy efficiency practices, and specific operational characteristics. Therefore, comparisons with other studies can provide insights into the emission levels and help identify trends or areas for improvement.

To decrease the carbon footprint related explicitly to LPG tenant usage in Sami Laris Swalayan shopping center, several areas for improvement can be considered. Firstly, increasing awareness and education among LPG tenant operators about the environmental impact of LPG usage and the importance of carbon footprint reduction is crucial. Conducting training sessions or workshops can educate tenants on energy-efficient practices, proper LPG usage, and emission reduction strategies. Secondly, encouraging LPG tenants to invest in energy-efficient equipment, such as modern and high-efficiency gas stoves, ovens, or fryers, can significantly reduce gas consumption and carbon emissions. Additionally, implementing a system to monitor LPG usage by individual tenants and regularly tracking and analyzing gas consumption patterns can identify opportunities for optimization and reduction. Feedback and guidance to tenants on efficient gas usage practices can further reduce emissions. Considering subsidy programs or incentives [17], [18] to incentivize LPG tenants to adopt energy-efficient practices can also be effective. This can involve financial support for upgrading equipment to more efficient models or offering discounts based on gas consumption reduction. Finally, encouraging collaboration among LPG tenants by organizing forums or discussions where they can share experiences, challenges, and successful strategies in reducing carbon footprint can foster a culture of collective action.

4. Conclusion

In conclusion, the research findings indicate that the consumption of LPG gas in small industries, explicitly resulting in emissions of 8.703 tons of CO_2 per year, highlights the significant contribution of LPG usage to carbon emissions. Furthermore, the linear relationship observed in this study suggests that as the usage of LPG gas increases, there is a corresponding increase in CO2 emissions. The emission level of 8.703 tons of CO_2 per year is an important benchmark for assessing the environmental impact of LPG usage in small industries, such as in Sami Laris Swalayan shopping center. It underscores the need for sustainable practices and energy-efficient measures to mitigate carbon emissions associated with LPG consumption.

Small industries must explore alternative energy sources, adopt energy-efficient technologies, and implement carbon reduction strategies to address these emissions. This could include promoting renewable energy, improving insulation and equipment efficiency, and encouraging adoption of low-carbon or carbon-neutral practices. Reducing carbon emissions from LPG usage not only helps mitigate climate change but also presents opportunities for cost savings, improved operational efficiency, and enhanced reputation as environmentally responsible businesses.

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