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Performance of Energy Efficiency in Medium-Scale Restaurant

Muhammad Amir Syauqi Mohd Zaid[1], Zamri Noranai[2,a*]

[1]Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, MALAYSIA

[2]Center for Energy and Industrial Environment Studies (CEIES), Universiti Tun Hussein Onn Malaysia, 86400, Batu Pahat, Johor, MALAYSIA

*Corresponding Author

Email: [a]zamrin@uthm.edu.my

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Abstract: This research focuses on enhancing energy efficiency in commercial restaurants, specifically evaluating the Richiamo Coffee Simpang Renggam, a medium-scale restaurant. The study aims to conduct an energy audit and evaluate the energy performance of the restaurant, with the goal of proposing solutions to enhance the performance of energy efficiency. Data collection involved a comprehensive site visit, including measurements, recordings, and interviews with staff members which providing two different data of April and May. The data obtained from the theoretical analysis is done by assuming the operating hours of the appliances used in the restaurant. The analysis revealed significant variations in energy consumption between the actual and theoretical, resulting in the energy distribution within the restaurant higher in the Dining Area which is 53.83% than Kitchen which is 46.17%. The 4 HP Air Conditioner, Coffee Machine, and Noodle Boiler were identified as main contributors to energy consumption in the restaurant. The comparison between theoretical and actual data confirmed the reliability of the theoretical analysis, supporting the recommendations for energy conservation measures that reduce 25% of actual consumption. These efforts align with the broader goals of energy conservation and minimizing the inefficiency of the restaurant's performance.

Keywords: Energy efficiency, Commercial restaurants, Energy audit, Energy consumption, Energy conservation measures

1. Introduction

In the dynamic landscape of the modern hospitality industry, restaurants play a pivotal role in meeting the evolving demands of consumers while also addressing pressing environmental concerns. One crucial aspect that has gained significant attention in recent years is energy efficiency in restaurants. As the world grapples with the challenges posed by climate change and the depletion of finite resources, the restaurant sector is increasingly recognizing the need to embrace sustainable practices. Energy efficiency not only contributes to cost savings for restaurant owners but also aligns with a broader commitment to environmental responsibility. This introduction delves into the significance of energy efficiency in restaurants, exploring how it can positively impact operational costs, environmental sustainability, and customer perceptions. As the industry strives to strike a balance between meeting customer expectations and reducing its ecological footprint, the integration of energy-efficient practices emerges as a fundamental element in shaping the future of sustainable dining experiences [1].

As the global population continues to grow, the demand for food services has risen substantially, placing a spotlight on the environmental impact of the restaurant industry. With the culinary landscape becoming increasingly competitive, restaurant owners are seeking innovative ways to not only enhance their bottom line but also to distinguish themselves as socially responsible entities. Energy efficiency, in this context, becomes a key strategy for achieving these dual objectives [2]–[4].

The restaurant sector is known for its energy-intensive operations, from cooking and refrigeration to lighting and HVAC systems. Embracing energy-efficient technologies and

**Corresponding author: zamrin@uthm.edu.my*

practices not only reduces operational costs but also mitigates the carbon footprint associated with daily operations. Recognizing this, many establishments are now adopting sustainable measures such as energy-efficient appliances, LED lighting, and improved insulation to optimize energy consumption [5].

Moreover, consumer preferences are evolving, with an increasing number of patrons expressing a preference for dining establishments that prioritize environmental stewardship. Restaurants that prioritize energy efficiency not only appeal to eco-conscious consumers but also contribute to the overall image and brand reputation of the establishment. The integration of energy-efficient initiatives can thus serve as a marketing advantage, attracting a growing segment of environmentally aware customers.

In this exploration of energy efficiency in restaurants, we will delve deeper into specific strategies and technologies that can be implemented to enhance sustainability, examining the economic and environmental benefits that accrue from such measures. As the industry faces the dual challenge of staying profitable while minimizing its ecological impact, the pursuit of energy efficiency emerges as a critical avenue for achieving a harmonious balance between business success and environmental responsibility.

Commercial restaurants can enhance their energy efficiency by focusing on their own practices. These establishments heavily rely on a range of electrical appliances and equipment for meal preparation. The initial layout of the commercial kitchen typically consists of a general section. Research by Mudie et al. (2016) [6] reveals that meal preparation activities alone account for an average of 63% of electricity consumption, with the evaluation indicating that 70% of this energy usage is excessive and could potentially be saved. It is worth noting that commercial kitchens consume 2.5 times more energy than other commercial areas, primarily due to the extended and energy-intensive utilization of kitchen equipment [7].

Assessing the energy efficiency of the diverse range of electrical appliances used in commercial restaurants is essential to optimize performance and minimize energy consumption. This research aims to investigate the energy performance of Richiamo Coffee Simpang Renggam, a medium-scale commercial restaurant, considering the challenge of balancing energy efficiency with the need for efficient meal processing during peak hours. Amantegui, Morais, and Pereira, (2022) [8] highlighted the lack of research on evaluating energy consumption in industrial kitchens, known for their high energy intensity.

This study aims to improve energy consumption forecasting in industrial kitchens by analyzing specific appliance consumption and comparing it to the combined energy consumption forecast (referred to as Virtual Aggregate or VA). The research employs three techniques. Data collected over four weeks from a restaurant in Portugal is used, focusing on energy consumption of specific appliances. The findings reveal that the Prophet and Random Forest methods are the most effective, with the Prophet method performing best for forecasting overall consumption and Random Forest for predicting energy usage of individual appliances. Additionally, forecasting overall consumption using data from individual appliances slightly outperformed forecasting each appliance separately, suggesting a feasible approach when only individual appliance data is available.

The research aims to achieve three objectives: conducting an Energy Audit on the current energy performance of the commercial restaurant, performing a comprehensive analysis comparing theoretical and actual data obtained from the restaurant, and proposing solutions and recommendations to enhance its energy performance. The investigation is limited to the medium-scale commercial restaurant, Richiamo Coffee Simpang Renggam, and focuses on measuring energy consumption from electrical appliances throughout the establishment. Analytical data obtained from Richiamo Coffee Simpang Renggam will be utilized for comparison with theoretical data during the data analysis process.

2. Materials and Methods

The study examines the performance of energy efficiency at Richiamo Coffee Simpang Renggam. It is located in the middle of Simpang Renggam Town, which is visible from the roadside and clearly can be seen when passing through Jalan Besar road. The research aims to conduct an energy audit, which involves discussions and conclusions to enhance the energy efficiency of the restaurant.

Typically, the kitchen has 2 staff members, while the dining area may have 2 or 3 staff members, although the exact number may vary based on specific restaurant needs. The staffing needs depend on availability and the unique circumstances of the restaurant. Richiamo Coffee Simpang Renggam operates daily, including on public holidays and weekends, from 9:00 a.m. to 1:00 a.m.

The commercial restaurant layout was thoroughly analysed during the study, with a focus on evaluating the placement of each electrical appliance in the dining area and kitchen. The power rate labels provided for each appliance were carefully considered to evaluate their energy consumption. The frequency of appliances usage is recorded by interviewing with the staff and person in-charge. This detailed assessment provided valuable insights into the energy consumption of electrical appliances.

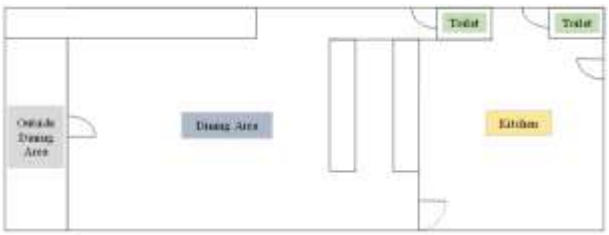

Fig. 1 – Floor Layout of Richiamo Simpang Renggam

3. Results and Discussion

A thorough data gathering approach was carried out over the course of two consecutive months, April 2023 and May 2023 in order to acquire insight into Richiamo Simpang Renggam's energy consumption trends.

3.1 Collection of Data

Based on Table 1, the actual Energy Consumption obtained from the Richiamo Coffee Simpang Renggam obtained. This proves that both of the months involve high and low energy consumption as there are annual festive events that occur during both of the month each.

There was a total of 70 electrical appliances in the restaurant, according to the data collection's findings. These appliances play a big role in the energy efficiency of the restaurant and affecting overall energy consumption. Accurate data on the operational hours of the appliances was obtained by noting how frequently they were used. Comparing the

information on the daily average operating times of electrical appliances in April 2023 and May 2023, some significant variations can be seen. The context of the fasting month of Ramadan in April, when customer presence is typically lower than in May, which also includes the festive occasion of Hari Raya Aidilfitri, must be taken into consideration.

Refrigeration appliances are designed to cool and preserve perishable items effectively. These appliances are estimated to operate for approximately 12 and15 hours for April and May daily due to the presence of a compressor. While these appliances may be plugged in and connected to a power source for 24 hours, their energy consumption is significantly influenced by the frequency of door openings. Every time the doors are opened, warm air from the surroundings enters the appliance, causing the compressor to activate and work harder to cool down the interior and restore the desired temperature. This repetitive cycle of door openings and compressor activation leads to variations in energy consumption throughout the day, making the estimated operating hours crucial in accurately assessing the energy usage of these refrigeration appliances.

Table 1 - Actual energy consumption for April 2023 and May 2023

No	Month	Date		Total Days	Energy Consumption (kWh)
		Billing Date	Billing Period		
1	April 2023	20-Apr-23	30 March – 20 April 2023	22	2184
2	May 2023	21-May-23	21 April – 21 May 2023	31	5733

3.2 Analysis of Energy Consumption of April 2023 and May 2023

Energy consumption that is contributed by each individual appliance will be calculate by multiplying the total power rate with the approximation operating hours. The formula for this analysis is as shown in Equation 1. The dining area's daily energy consumption in April 2023 was 56.09 kWh, compared to the kitchen area's consumption of 45.31 kWh. When these areas are summed up, the restaurant's overall daily energy consumption results to 101.39 kWh. However, in May 2023, the kitchen area's daily energy use increased to 86.05 kWh, while the dining area's consumption increased to 100.32 kWh. As a result, in May 2023, the restaurant's overall daily energy consumption was 186.37 kWh. In April 2023, the total energy consumption for the month is 2230.67 kWh for 22 days, whereas in May 2023, it increases to 5777.50 kWh for 31 days of billing cycle. This represents a significant increment in energy usage

$$\text{Energy consumption per day (kWh)} = \text{Total power} \times \text{estimated operation hours} \quad (1)$$

3.3 Energy Load Apportioning

Due to its higher total energy consumption compared to April 2023, May 2023 is chosen as the reference month for calculating the percentage of Energy Load Apportioning for each appliance. More thorough understanding can be obtain on how energy is distributed among appliances by focusing on May 2023, a month with higher energy consumption. The evaluation of Energy Load Apportioning helps in understanding the energy distribution within the restaurant which can be refer in Figure 2.

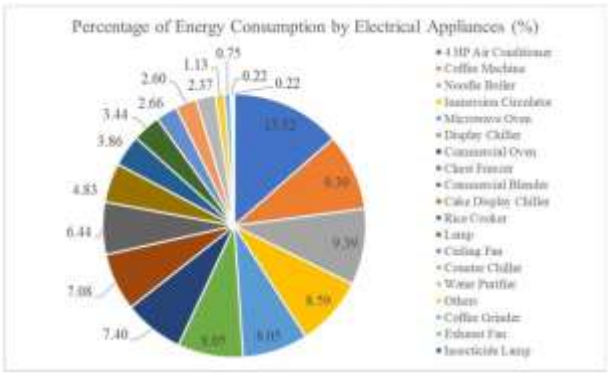

Fig. 2 – Pie Chart of Percentage of Energy Consumed by Richiamo Coffee Taman Merdeka's Electrical Appliances in May 2023

3.4 Theoretical v.s. Actual Energy Consumption

The comparison between the theoretical and actual data, displayed in Table 2 demonstrates a reasonable agreement, as the total energy consumption per day for the entire restaurant falls within a tolerance of ±3 kWh. Thus, for April 2023, Energy Consumption is required to fall between 96.27kWh to 102.27kWh while for May 2023, between 181.93 to 187.93. This indicates that the theoretical analysis based on approximation of operating hours provides a reliable estimation of energy consumption.

Table 2 - Summarize Table for Theoretical Data v.s. Actual Data of Energy Consumption

No	Month	Total Days	Average Daily Energy Consumption (kWh)		Monthly Energy Consumption (kWh)	
			Theoretical	Actual	Theoretical	Actual
1	April 2023	22	101.39	99.27	2230.67	2184
2	May 2023	31	186.37	184.93	5777.50	5733

3.5 Energy Conservation Measure

Energy Conservation Measure focuses on energy conservation solutions for the top three appliances that consume a significant amount of energy in the Richiamo Coffee Simpang Renggam. The 4 HP Air Conditioner, Coffee Machine, and Noodle Boiler have been identified as the main contributors to energy consumption which can be refer to Table 3. Implementing energy-saving measures for these appliances, we can increase the efficiency of the performance and enhance the sustainability. The aim is to reduce energy consumption without affecting the current performance, lower utility costs, and contribute to a greener and more environmentally conscious operation of the restaurant.

The percentage of energy consumption reduction needed to enhance the efficiency of appliances can vary depending on the specific appliance and its current energy usage. However, in general, the goal is to achieve the highest possible energy efficiency by minimizing wasted energy. This typically

involves aiming for significant reductions in energy consumption, which is 25%.

Optimizing energy usage in a commercial restaurant involves implementing strategies for the air conditioner, coffee machine, and noodle boiler. For the air conditioner, maintaining moderate temperature settings, proper insulation, regular maintenance, and using programmable timers enhance efficiency. Similarly, conserving energy for the coffee machine includes maintenance, adjusting brewing quantities, and staff training. For the noodle boiler, regular cleaning and bulk boiling of noodles improve energy conservation. These measures collectively contribute to reducing unnecessary energy consumption and enhancing overall energy efficiency in the restaurant.

Table 3 - Top Three Electrical Appliances Energy Consumption Before and After Energy conservation Measure

No	Electrical Appliances	Energy Consumption (kWh)		Potential Energy Consumption (kWh)
		Day	Month	Month
1	4 HP Air Conditioner	25.20	781.20	585.90
2	Coffee Machine	17.50	542.50	407.03
3	Noodle Boiler	17.50	542.50	407.03

4. Conclusion

Based on the comprehensive data collection and analysis conducted at Richiamo Coffee Simpang Renggam, the energy consumption patterns of the restaurant's electrical appliances have been identified. The findings reveal significant variations in energy usage between the dining area and kitchen, as well as noticeable changes in energy consumption from April to May 2023. In April, the dining area accounted for 55.32% of the total energy consumption, while the kitchen area contributed 44.68%. However, in May, the dining area's energy consumption increased to 53.83%, surpassing the kitchen area's 46.17%. This can be concluded that the Dining Area consumes more energy than Kitchen Area. The 4-HP Air Conditioner emerged as the highest consumer, followed by the Coffee Machine and Noodle Boiler, which were the key contributors to energy consumption. These findings provide valuable insights into energy usage patterns, allowing the restaurant to improve energy management and implement energy conservation measures for specific appliances.

Next, to enhance energy efficiency, strategies such as maintaining moderate temperature settings, proper insulation, regular maintenance, and utilizing programmable timers and smart controls can be implemented for the 4 HP Air Conditioner. Moreover, measures like adjusting brewing quantities, staff training, and regular maintenance can be employed to conserve energy for the Coffee Machine and Noodle Boiler. The analysis also revealed the importance of bulk boiling for the noodle boiler, which enhances energy usage by minimizing idle time and improving capacity utilization. Proper storage of excess noodles is essential to maintaining their quality. These insights enable the restaurant to make firm decisions and optimize energy management practices, reducing energy consumption and operational costs while striving for sustainability.

By examining the theoretical data against actual energy consumption measurements, the study confirms the reliability energy audit of the theoretical analysis based on the approximation of operating hours. The actual energy consumption aligned reasonably well with the theoretical values, falling within a tolerance of 3 kWh per day. This evaluation further emphasizes the importance of the findings and recommendations, allowing Richiamo Coffee Simpang Renggam to implement effective energy management strategies and improve energy efficiency across the restaurant. Overall, this study provides a solid foundation for enhancing the performance of energy efficiency, reducing costs, and achieving sustainability goals in the long run.

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