ADOPTION OF CLEANER PRODUCTION CONCEPT IN HAWKER CENTRE

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ADOPTION OF CLEANER PRODUCTION STRATEGY IN HAWKER CENTRE

ABSTRACT

Hawker centres are commonly found in Malaysia and the facilities operations may contribute to significant fraction of carbon footprint from food industries. In this work, Cleaner Production (CP) audit was conducted at a hawker center to quantify the energy usage, fuel and resources consumption, raw material usage and generation of waste. A hawker centre located at Kepong, Kuala Lumpur was selected to identify the Cleaner Production (CP) Strategy that aims to produce a greener hawker. According to the audit finding, the normal operation of hawker centre generates 1.18kg CO2 per customer which were contributed by 53% food waste, 28% LPG fuel consumption and 14% electricity usage. The remaining are contributed by 6% of solid waste and 2% is by the wastewater production and water usage. From the findings, a total of 30 CP options were identified with 18 of it were suggested for cleaner production implementations based on considerations of the cost and improvement in carbon emission reduction. Through the carbon footprint calculation, the implementation of the CP options cut the carbon emission from 1.18 kgCO_2 to 0.82kgCO_2 per customer which equivalent to 31% of reduction. The estimated investment cost required for the implementations of suggested CP options is sixteen thousand Ringgit Malaysia with payback period of 1 year and 3 months. Therefore, implementation of CP options was beneficial to reduce carbon emission and produce a greener hawker.

Keywords: carbon emission. Cleaner production, hawker centre , waste management, carbon footprint

PELAKSANAAN STRATEGI "CLEANER PRODUCTION" DI PUSAT PENJAJA

ABSTRAK

Pusat penjaja makanan sering ditemukan di Malaysia dan operasi fasiliti tersebut boleh menyumbang kepada sebahagian ketara jejak karbon daripada industri makanan. Dalam kerja ini, audit pembuatan bersih (CP) telah dijalankan di pusat penjaja untuk mengukur penggunaan tenaga, bahan bakar dan penggunaan sumber, penggunaan bahan mentah dan pengumpulan sisa buangan. Sebuah pusat penjaja makanan terletak di Kepong telah dipilih untuk mengkaji strategi "Cleaner Production" (CP) yang bertujuan untuk menghasilkan pusat penjajaja makanan yang lebih mesra alam. Berdasarkan penemuan audit, operasi biasa pusat penjaja makanan menghasilkan 1.18 kgCO2 bagi setiap pelanggan yang disumbangkan daripada 53% sisa makanan, 28% penggunaan bahan api LPG dan 14% penggunaan elektrik. Baki adalah disumbangkan daripada 6% sisa pepejal dan 2% daripada penghasilan sisa air dan penggunaan air. Daripada penemuan tersebut, sejumlah 30 CP opsyen telah dikenalpasti dengan 18 pilihan daripadanya telah dicadangkan untuk perlaksanaan pembuatan bersih berdasarkan pertimbangan ke atas kos dan penambahbaikan pada pengurangan perlepasan karbon. Melalui pengiraan jejak carbon, perlaksanaan pilihan CP dapat mengurangkan perlepasan karbon dari 1.18kgCO_2 kepada 0.82 kgCO_2 untuk setiap pelanggan yang setara dengan penunuran sebanyak 31%. Anggaran kos pelaburan yang diperlukan untuk pelaksanaan opsyen CP adalah enam belas ribu Ringgit Malaysia dengan tempoh pembayaran balik sebanyak 1 tahun dan 3 bulan. Oleh itu, pelaksanaan pilihan CP bermanfaat untuk mengurangkan pelepasan karbon dan menghasilkan penjaja yang lebih mesra alam.

Kata kunci: Pengeluaran karbon dioksida, "Cleaner Production" pusat penjaja makanan, pengurusan sisa, jejak karbon

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

^{o}C	:	Degree Celsius
CH_4	:	Methane
CO_2	:	Carbon dioxide
CP	:	Cleaner Production
DOE	:	Department of Environment
GHG	:	Greenhouse gases
GWP	:	Global Warming Potential
kWh	:	Kilowatt hour
kg	:	Kilogram
N_2O	:	Nitrous Oxide
RM	:	Ringgit Malaysia
ROI	:	Return of Investment
SMEs		Small and medium-sized enterprises
SWCorp	:	Solid Waste Management and Public Cleansing Corporation
UNEP	:	United Nations Environmental Program

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CHAPTER 1:INTRODUCTION

1.1 Introduction

Food hawking are vital source of income for the public significant contributor to the economy, and also an important cultural heritage in Malaysia. Hawker foods prepare by small entrepreneurs. is an economical meal for society as it often comes at a relatively low price and it also a tourist attraction due to its unique existence in South East Asia. It is also a valuable image of locals specialties in the era of internationalization and transnational migration, securing heritage recognition in many places as it portrays history and tradition also demonstrating to tourists a cultural way of life. Hawker foods are normally sold at roadside or open-air complexes and often located in urban centre, near public housing estates, adjoining with wet markets and transport hubs for the purpose of allowing their customer to dine-in or takeaway.

With the expanding in types of food hawkers, its definition of it becomes indistinct. Thus, the Kuala Lumpur City Hall has grouped hawkers' businesses accordance to the type of building that they accommodate and the location of their operation, thus consisting of five categories which include: "stalls", "hawker centres", "kiosks", "night markets", and "food courts" (Hassan, 2003). Hawker centre, coffee shop and food court are commonly visited by Malaysian due to variety of choice. However, there are a major difference between them which is the size and place of their operation. Hawker centre and food courts usually larger in size with many hawker stalls, whereas for coffeeshops or commonly known as Kopitiam in Malaysia and Singapore are typically smaller in size. Commonly, coffeeshop are locates in a single or double shophouses whereas food courts and hawker centres to be at detached or larger buildings. The main difference between food court and hawker centre is food court locates at the indoor with air conditional such as shopping centre.

Food hawking is considered as one of the remunerative businesses in Malaysia and the growth of the hawker population is increasing each year. It is also considered as an informal business activity compared to a formal business activity, especially as it short of certain requirements such as business permits and tax reports, as well as often absent of fulfilment to labor regulations governing the work condition and employment contracts (Cross, 2000)

Hawker centre had also brought problems to public health and environment. Large amounts of utilities such as fuel gas, electricity and water are consumed during the operation of hawker centre. Besides, hawker centre also involves high usage of plastic products for takeaways. takeaways. For example, a takeaway of noodle soup requires three different plastic bags. Two plastic bags to separate packaging of soup and noodle and another plastic bag with handles are used for the ease of carrying. Food waste, solid waste, wastewater, hazardous waste will also be generated during the operation of hawker centre. All these activities contribute to the increase in emission of greenhouse gases (GHGs) which will lead to global warming. Therefore, it is important for hawker centre owner to practice greener operation to prevent global warming and reduces the waste produced from the hawker centre.

1.2 Problem Statement

Foods from hawker centre are not only appreciated for their unique flavors, convenience, and the role which they play in the cultural and social heritage of societies, they are also become important and essential on providing nutritional status of the population. However, hawker centres are perceived to be a major public health risk and environmental issue. Hawker centres are one of the industries that contribute the high usage of plastic products especially for takeaways order and gas fuel, water and electricity are consumed during the operation of hawker centre. Waste such as food waste, hazardous waste, wastewater and GHGs will also be generated during the operation of hawker centre. There are limited literature and study being conducted on hawker centre targeting environmental impact and greener approach on hawker centre operation. Therefore, this study is important to identify the methods to improve the operation of hawker centre through greener approach.

1.3 Research Question

Based on the identified research problems, several research question can be raised as follow:

i. What are the activities that contribute to the carbon footprint in hawker centre?
ii. What is the carbon footprint generated at hawker centre per customer basis?
iii. What are the CP options that can be used to reduce the carbon footprint produced in the hawker centre?
iv. Are the suggested CP options environmental and economical feasible?

1.4 Aim of the Study

The aim of this research study is to green hawker activities with application of cleaner production strategy.

1.5 Objectives of the Study

To achieve the aim research study, objectives were formulated as follows:

i. To conduct CP audit at selected hawker centre
ii. To generate CP options that promote greener operations at hawker centre
iii. To determine the carbon footprint generated before and after implementation of CP option.
iv. To evaluate and prioritize CP option that can be implemented

1.6 Scope of the Study

This research study is conducted at hawker centre located in Klang Valley and focuses on the operation activities in the hawker centre premise. The research study will include preliminary site visit to hawker centre, performing CP audit and generation of CP option suggestion to hawker centre. This study also includes the calculation of carbon footprint per customer based on the resources and utilities consumption and waste generated.

1.7 Significant of Study

The finding of this research study is to identify the operation activities in hawker centre that contribute most environmental impact. The study will identify and proposed cleaner production strategies to improve the current operation of hawker centre.

1.8 Report Layout

Chapter 1: Introduction

In this chapter, an overview of food hawking, function of hawker centre and environmental impacts brought by hawker centre had mentioned. The research questions, aim, objectives, scopes are included and explained in this chapter.

Chapter 2: Literature Review

In this chapter, literature review on background of hawker centre, current rules, and regulations that governing hawker centre, environmental and health impact brought by hawker centre, overview of cleaner production and cleaner production approach on industry.

Chapter 3: Methodology

This chapter includes the method and technique used to collect data that requires for this study. A detailed cleaner production audit methodology, calculation of carbon footprint, method of calculation on payback period and CP generation was included.

Chapter 4: Result and Discussion

This chapter discuss on the audit result analysis and CP option will be proposed accordingly. Calculation of carbon footprint and ROI evaluation will also be performed to identify the feasibility of CP option.

Chapter 5: Conclusion

This chapter highlights the finding of the research and determination of initial objectives was met. Suggestion for future studies will also be provided.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Since the industrial revolution there is an upsurge of various human activities that resulted in enormous amount of energy resources being consumed within short period of time. Mass production and consumption of resources have brought significant effects to the environment by depletion of non-renewable resources and polluting the environments through soil, air and water. According to Gandhi et al. (2006), the four major factors that contribute to the environmental degradation are industrialization, per capita income increase that causes the consumption pattern changes, depletion of natural resources and population growth. However, there are numerous ways can be implemented to reduce the effects causes on the environment. These included achieving environmental performances optimization through performing total quality management, application of end-of-pipe technique, recycling waste produces, substitution of non-renewable resources and adaption of cleaner production concepts.

Hawker food or commonly known as street food, are defined as food that “ready-to-eat” or prepared when requested for takeaways or consumption at site which prepared by small vendor. (Food & Organisation, 1989). According to Hilmi (2019), there are estimated 2.5 billion of people consumed street food every day and it considered the most selection for public dining. Hawker foods are considered low-priced meal compared to restaurant foods. Hawker food has become an important food distribution system, specifically for midday meals in both developed and developing country (Organization, 2010). Besides, food hawking sector had provided employment opportunities for people with inadequate skill or education and limited financial capital. Despite many advantages provided by food hawking, however it also brought significant impacts on environment and public health risk.

2.2 Food Waste

With the living nature of human, food waste is being discarded through agricultural, domestic, and industrial activities. Food waste can be categorized into three category which are food losses, unavoidable, and avoidable food waste. Food losses are defined at the food materials lost during the food preparation and cooking process. For the unavoidable food waste, it defined as the inedible part of the food material for examples, potato peels, fruit core, bones etc. Surplus and wastage of food which are still edible conditions are defined as the avoidable food waste (Thi et al., 2015)

In Malaysia there are 38,000 tons of domestic waste daily and 45% approximate 17,000 tons are food waste and out of that 4,080 tons are edible food waste (The Stars, 2021). Interview conducted by Tan (2011), quoted that F and the consumers are not even concern on the amount of food that there are wasted. According to Malaysia Solid Waste and Public Management Act 2007 (Act 672). Food waste disposal is categorized under disposal of solid waste and the disposal method can be either incineration, destruction, decomposing or deposit (Nagapan et al., 2012). Landfill is the most common and widely accepted method on managing food disposal due it is simple and cost effective. However, Moh and Abd Manaf (2014) reported that managing food waste through landfilling had become more difficult as many landfill had reached their capacity in Malaysia. Whereas for the case of incineration, incinerating food waste via incinerator will lead to air pollute on and the process is more costly as it requires high technology and energy usage. The authority of Malaysia is facing challenging situation on handling and treatment of food waste. The improper separation of food waste from municipal solid waste had contributes of generation of greenhouse gases in landfills which will lead to climate change.

According to UN secretary General, food waste will lead to climate change and food security and the impact is observed at an alarming level. Food waste produces greenhouse gases which contribute to climate change and eventually affecting food production. Besides, food wastes caused lots of environmental issues such as when the pollution and waste produced surpass the earth's capabilities to adapt and digest, it will lead to reducing irreversible resources such as water and soil which eventually threatens the ecosystems. To promote the awareness of public on food waste issue, program such as 3R I (Reuse, Reduce and Recycle) was introduced through education and respective incentive program had been launched.

2.3 Environmental Issues from Plastic Usage

Petrochemical plastic which acts as effective protection from water vapor, carbon dioxide and oxygen, good in tensile strength and cheap in price is commonly use in food packaging industry. Food packaging are commonly designed for single use will be thrown away rather than recycle and reused. (Bodamer, 2016) With the Covid-19 pandemic happening around the world, the usage of plastic as takeaway container had upsurged due to most countries are having lockdown where dining-in is not available. Even before of the pandemic occurs, the restaurant industry has been the major usage of single-use plastic with the forms of straws, drinking cup, cutlery and food container compared to other industry (Pirani & Arafat, 2014). Previous studies conducted by Cassidy and Elyashiv-Barad (2007) mentioned that in USA there are over 7.5 billion of extruded polystyrene containers are used annually which resulted of 297 Mt CO_{2eq} being generated annually.

After the takeaway food being consumed, most packaging will be disposed and be buried in a landfill, however the degradation process of plastic takes many years. Besides, toxic substances will be released into the soil when plastic bags decease when exposed to sunlight. Whereas burning of plastic will caused release of released toxic substance into the air and lead to air pollution. For the case of improper disposal of plastic packaging such as plastic bag will affect the environment causing blockage of stormwater drain and littering. Besides, animal health will also be threatened as animal wrongly consumed plastic bag as food which lead to blocking in their digestive systems. According to the research conducted by Katsanevakis (2008) , there are large amount of endangered turtles found to suffocated due to swallowing seaweed together with plastic bags. Thus, improper disposal of plastic will lead to worsening of marine environment.

2.4 Foodborne Disease

Foodborne diseases are accountable for the most illness and mortality in worldwide. According to Organization (2015), 30% of population from the industrialized countries suffer from foodborne illness annually. There are 250 different kinds of foodborne illnesses and individuals will suffer from it when consumption of water or food that contaminated with potential foodborne pathogens. Approximately 1 out of 6 or 48 million of individuals fallen sick due to foodborne diseases annually. Within the 48 million individuals, 3000 individuals die and 128,000 individuals hospitalized due to foodborne related disease. (Scallan et al., 2011)

The changes in lifestyle of preferring dining out than home cooking in Malaysia, especially the urban dweller is caused by the attractive and various choices of food available from the foodservice industry. This eventually led to the upsurge growth at the local food service industry. With the growth of the food service industry, the demand of manpower had increase resulted in increase of hiring of migrant worker from 6.6% in year 2000 to 11.9% in year 2013. Unfortunately, with the growth of food service industry also brought an upsurge trend on foodborne disease and half of the reported disease had a direct linkage of insanitary on food handling. (Woh et al., 2016). Poor hygiene and mishandling of food will facilitate the transmission of foodborne pathogens from farm to folk which includes the stages of food production, processing, packaging and distribution of food (Rall et al., 2010), hence allowing the pathogens to contaminate the edible products. For the case of Malaysia, the incidence of having foodborne disease is reported with an approximate of 60.97 cases out of 100,000 population, with most of the cases denoted as food poisoning at rate of 45.71 and the mortality of foodborne disease is 0.02 (Ministry of Health Malaysia MOH, 2019). Usage of untreated water during food and beverage preparation, unhygienic food handling practices and poor environment cleanliness are the major factor contribute to the foodborne disease.

For improve the understanding of food service vendor on the importance of food safety, a training program administered under the Food Act (1983) and Food Regulation (1985) was introduced in Malaysia. The training program is a 3-hour program which target on education of food handlers on importance of cleanliness of food premise, food safety and personal hygiene on prevention of foodborne disease. In Malaysia, there were no specific guidelines or certification of greener operation provided for restaurant owner or operator to use as a reference. However, there are presence of Cleanliness Certificates that classified into three bands; Grades A recognized as the highest grade, grade B for moderate and grade C for low cleanliness. Local authorities will award the certificates to restaurant that adhered to the standards of hygiene practices and clean premises. Despite the cleanliness program in place and total of 151,198 of food handlers and restaurant premise owner being trained and educated in 2012, but there are reported 132,529 food service premise being shut down due to bad hygiene practice in the premise under Section 11 of Food Act (1983) (Woh et al., 2016).

Table 2.1 Cleanliness Grading system on food premise by local authorities

`	Action
Grade A: 76 – 100%	Clean. Inspection process will be performed once a year
	Inspection regime will change when the grade decline
Grade B: 50 – 75%	Moderate cleanliness, inspection process performed once every 6 months
	If the grade remained, inspection process will occur every 6 months
Grade C: 49% and below	Poor in cleanliness and ordered for closure for 2 weeks' time. Premise will only allow to operate when cleanliness improved.
	Inspection process will occur every 6 months.

2.5 Climate Change and Global Warming

With the increase of atmospheric greenhouse gases level, global warming is happening, and it is happening fast and inevitable. Greenhouse gases includes carbon dioxide, methane, water vapour, nitrous oxide and other greenhouse gases. These gases act as a blanket by gripping the infra-red radiation and prevents it to escape to outer space. The average temperature has increased up to 0.5°C globally during the 20^{th} century. The average air temperature was estimated to further increase 1.5 to 4.5°C by year 2100. (Misni, 2012). Fossil fuel combustion attributes to the increased of atmospheric carbon dioxide level.

Like other countries, Malaysia is also facing the risk of global warming and climate change. Over the last 4 decades, Malaysia is experiencing 0.18°C of temperature increase per decade and increase in sea level. (Tiong et al., 2009) Depending on the GHG emission level, Malaysia had potential increase of 3 to 5°C. The increase of temperature will affect the agricultural sector in Malaysia. According to MOSTE (2000), with every 1°C raise in temperature, there will approximation of 10% reduction on paddy production. The massive urbanization had affected the Malaysia environment and greenhouse gases had become a major concern. Industrial and business activities such as metal, petrochemical, power plants, oil and gas are the sources responsible for the climate change and global warming in Malaysia.

2.6 Carbon Footprint

Carbon footprint is expressed and defined as the global warming potential (GWP) of the greenhouse gases released to the environment during lifecycle of products. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide(N_2O) and fluorinated gas that contribute to the greenhouse effect. Global warming potential is the measurement of heat that is retained in the atmosphere with a certain gas relative to the amount of heat trapped by carbon dioxide. Value of GWP for a specific gas is depending on how efficiently, gas absorbed in which infrared radiation and the lifespan of the specific gas in the environment. GWP is commonly expressed in terms of CO_2 equivalent (CO_2eq) for different greenhouse gases and the value depends on the time interval considered. An interval of 100 years is commonly used for the carbon footprint calculation. The total carbon footprint can be calculated by adding the total GWP of various gases together. (IPCC, 2007)

$$CF = \text{Amount of } CO_2 * 1 + \text{Amount of } NO_2 * GWP_{N2O} + \text{Amount of } CH_4 * GWP_{CH4}$$

Table 2.2 GWP for different gasses with different time perspective (IPCC, 2007)

Gas	20 years	100 years	500 years
Methane, CH_4	72	25	7.6
Nitrous oxide, NO_2	289	298	153

2.6.1 Carbon Footprint from Food Preparation

Food preparation and Previous conducted by Sims (2011) mentioned that food system responsible of up to 30% of global energy use. Besides the huge amount energy required for ensuring the sufficient supply of food chain, food system are accounts for one 1/3 of the anthropogenic release of greenhouse gases such as methane, nitrous oxide and carbon dioxide which gives a direct impact on the climate change. Studied performed by Tukker and Jansen (2006) also mentioned that 20 to 30% of the greenhouse gasses emission is related to food production and food consumption However, consumers are still unclear and lack of information on about the climate impact on the food choices that they eat (Hartikainen et al., 2014). Thus, study of food systems had attracted large attention concerning greenhouse gasses emission and energy use targeted on identifying the stages where the improvement can be made and develop strategies on combating climate change.

For food production, the lifecycle inventories of greenhouse gasses emission and energy use provided are usually specified with the unit of per unit of food produced in kilograms (kg) or pounds (lbs.) for the calculation of carbon footprint. This indicator is commonly used to assess the sustainability of agricultural sector where how many units of energy and GHGs is emitted with produced the amount of food. As food serve as a source of nourishment to human, study conducted van Dooren et al. (2017) includes the nutritional indicators to investigate the relationship between climate change, agricultural, and public health. For example, protein gained per unit greenhouse gasses produced emitted as function of food protein content was performed (González et al., 2011).

Plant-based food have found to be contribute less contribution to energy usage and emission of greenhouse gasses compared to the animal-based food. (Hallström et al., 2015). However, lifecycle of cradle to wholesale point conducted by González et al. (2011), found that the amount of protein obtained per unit of energy used for wheat and soybeans were 6- and 17 times greater obtained from the beef. Agricultural stage is usually accounts for the highest emission of greenhouse gasses and energy use in the food production system, subsequently food handling and transportation. Carbon footprints are commonly only performed at the stage of cradle to distribution centre and omitting the steps leading to consumption such as storage, cooking, and transportation. These is caused by the complication of the system and lack of specific data on the downstream process where there will be mass changes on each specific food and depending on the cooking method and time. Due to the lack of specific data on the food preparation process, cooking energy consumption was estimated based on the national surveys of residential energy use. There are total of 14% of total energy usage in a household is used for cooking in the UK (Zimmermann et al., 2012), whereas in the US, it was estimated that the cooking meals with microwave oven, oven and stove requires about 20% of food-related energy in the household (Heller & Keoleian, 2000).

Changes of mass in food chain can be relevant, however this field is still understudied at the aspect of food lifecycle studies. Grains such as legumes and cereals will lose about 10% to 30% during the process of polishing, milling, and drying, however, when soaked and cooked large mass gained was observed. Considerable variations of food weight were found during the food preparation and cooking stage which effect the energy use and greenhouse gasses released to the environment. During the cooking process, grains gained weight after the cooking process due to water absorption (Goucher et al., 2017) while meat lost weight during the cooking process. This is because when meat exposed to the raw meat, shrinkage of meat and melting of fat will produce slow contraction in the volume which will then resulted in the rupture of meat cells and exudate of soluble and water components from the meat. (Pathare & Roskilly, 2016)

2.6.2 Reducing Carbon Footprint at Food Service Sector

By examining the food service sector, a total of 5 main stages which consider the major contributor to environmental impacts. The five main stages include food production, transport and distribution, food consumption and waste disposal. For reduction of negative impacts from the food production phase of food service sector. The first approach is through food procurement method, where food vendor will prioritize the purchase of produced food material with higher environmental production standard. Besides, the second strategy target on redesigns the available menus and preparing the. meal using more low-impact ingredients such as plants food compared to high-impact ingredients, animal based. Study conducted by Cerutti et al. (2018) mentioned that changing the available menu by replacing meat-based meal with vegetarian meals can achieved total of 32% of carbon footprint reduction whereas for the case of changing the sourcing raw material method by prioritize the improved production practice such as integrated or organic production, and buying form the regional market will have a reduction of 11% and 0.2% if respectively.

For the cooking process, cooking method can be lentils and unmodified to reduce the energy usage which eventually reduce emissions of greenhouse gasses. According to research conducted by Arrieta and González (2019), there are a significant difference of the energy used and carbon emission for the energy used during the cooking of soaked (1.7MJ and 0.095kg CO_{2eq}) and unsoaked lentils (2.9MJ and 0.162kg CO_{2eq}). Therefore, is preferred to soak grains product before cooking. Besides, the cooking appliances will also affect the greenhouse gasses emission and energy use. A kilo of meats cooked with oven (9.3MJ and 0.52 kgCO_{2eq}) will used more energy and higher greenhouse gasses emission as compared to the meat cooked on the stove (5MJ and 0.28 kgCO_{2eq}).

For the case of overall operation of food service sector, it is recommended to use energy-efficient and water-efficient appliances. The most common example is replacing the incandescent bulbs and fluorescent lamps with the LED lighting system this is because incandescent generates 4500 lbsCO_{2eq} per year, fluorescent lamp generates 1051 lbsCO_{2eq} per year while LED bulb only generates 451 lbsCO_{2eq} annually (CPS LED, 2017). Besides, for the water-efficient appliances, it is recommended to install flow restrictors on faucets and low-flow toilets to prevent any wastage of water.

2.7 Case Study on Greener Food Service Industry

Food service industry have developed greening initiatives to produce more sustainable gastronomy and safer environment to their employee and customer. Therefore, the greener initiative proposed at food service industry as further understanding and identify the feasibility of application at hawker centre.

2.7.1 Rifrullo Café in Brookline

Rifrullo Café locates at Brookline is a 3-star Certified Green Restaurant recognized by the Green Restaurant Association. To achieve the sustainability of the restaurant few practices had been applied to reduce the environmental impact.

In restaurant business, wastewater is the most inevitable waste. Water is not solely used in the cooking process but additionally of customer that contributes to the extra water use such as using the bathroom and turning off the water after washing hand. To reduce the wastewater generated, aerator was installed at every sink of Rifrullo Café. Aerators allows air to mix with the stream of water from faucet and allow the water to appear high pressure while significantly decrease the actual water usage. However, installation of aerator must be complied with the standard of 1.5 gallons per minute for kitchen usage and 0.5 gallons per minute for customer usage in bathroom.

Food waste and solid waste are also unavoidable aspect during the operation of restaurant. At Rifrullo Café, composting was used to limit the generation of food waste. Composter used at the restaurant not only collect food waste but even solid waste such as wax paper and wood materials like chopsticks and toothpicks. To prevent contamination of the composter, a clear signage with pictures and educations was provided to the staff which allows the staff to think about the entire lifecycle of food prepared. Rather than throwing the food waste and solid waste to the landfill, it can be composted and repurposed back to Earth which reduces the GHG emissions.

Instead of focus on recycling, Rifrullo emphasizes on no single-use product during the café operation. Reusable dishware was used for dine-in customer and utilize glass jars for takeaways soup orders. Besides, application of high temperature dishwashing can reduce the consumption of hazardous chemical and allowing the process as green as possible. With the high demand of takeaway order, biodegradable utensils and container was provided, besides, family size meal is encouraged for better used of the container. To further reduce the plastic waste, there are no water bottles being sale at the restaurant and plastic straws are being removed.

Besides, Rifrullo designed their menu in sustainable way by providing the meal 43% of vegetarian meal and another 14% of the dish are entirely vegan. Reducing the meat consumption is enormously impactful for business carbon footprint.

Besides from the waste production, procurement of food and other materials also the key to create sustainable restaurant. Purchasing locally grown food methods reduce the transportation emission while supporting the local farmer which creates greater community value. Whereas for the purchase of materials requires during the restaurant operation, always choose the most environmentally friendly item in the market and prioritized materials that made from recycled materials. By taking these steps, a more sustainable operation can be achieved.(Maslan, 2019)

2.8 Cleaner Production

According to the United Nations Environment Program (UNEP), cleaner production is defined as the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce the risk to humans and the environment. Cleaner Production can be applied to any industry, to product and services provided to the society. For production processes, cleaner production can include conserving raw materials and energy, eliminating toxic substances, reduces the quantity of pollutants and toxicity of waste before discharge (Frondel et al., 2004; R et al., 2007). For products, the cleaner production strategy will focus on diminish the impacts along the entire life cycle of the product, which are from the extraction of raw material to final disposal of the product. For services, cleaner production strategies can be incorporating environmental concerns when designing and delivering services. In cleaner production concept, resources are required to be managed efficiently. Below are the main principles fall under the concept of cleaner production:

i. Waste Reduction and Elimination

In cleaner production concept, all types of waste including hazardous waste, resources waste, solid waste, liquid and gaseous waste, waste heat etc. and these wastes can be avoided by perform modification on inputs material, water, and energy, for example, hazardous waste can be reduced by substitute materials to less hazardous type.

ii. Non-Polluting Production

Cleaner production promotes ideal production process where the concept of CP take place in a closed loop with zero contamination release. This can achieve by internal recycling which includes reutilization of materials for the same purpose, reclaiming of high value materials or closing of loops system for water usage or transforming waste into useful by-product

iii. Production Energy Efficiency

Cleaner production involves the highest degrees of energy conservation and efficiency. Energy efficiency can be calculated by the largest ratio of energy consumption to product output. Whereas energy conservation represents to the reduction of energy usage. The production energy efficiency can be achieved by promoting good housekeeping in the workplace.

iv. Working Environment

Cleaner production strives to diminish the risks of employees to make the workplace a healthier, cleaner, and safer environment.

v. Environmentally Sound Products.

The final product and all marketable by-products from the production should be as environmentally appropriate as possible. Health and environmental factors must be adopted at during the whole life cycle of the product which from the earliest phase of product and process design to the raw material usage and product production through use and disposal.

vi. Environmentally Sound Packaging

Product packaging should be diminished wherever possible. However, for packaging that used to protect the product, to market the product, or to facilitate ease of consumption, it should be as environmentally appropriate as possible.

2.8.1 Significant of Cleaner Production

Environmental concerns are managed in a more comprehensive and efficient manner with the introduction of cleaner production (CP) concept. In environmental aspect, cleaner production approach plays an important role in addressing global environmental issues, urban smog, climate change and acid precipitation. CP concept encompasses at every stage of manufacturing process had encourages the manufacturer to develop a more comprehensive prevention strategy primarily on handling environmental concern at production cycle and product development phase (Yusup et al., 2013). Besides, realization of circular economy with the implementation of CP concept as it promotes sustainable production practice (Li et al., 2011). Cleaner production approach brought great importance for policy maker to make decision on the field of environmental management and policy.

In economically aspect, application of cleaner production concepts is economically feasible in most cases. Prior experience with adaption of cleaner production strategies had proven that further environmental damage can be averted in a cost-effective manner. Application of cleaner production technique are beneficial in term of emission of pollutants such as carbon dioxide etc. as cleaner approach focus on long-term reduction and elimination of pollutants where waste will be eliminated before it is produced which lead to reduction at cost of treatment (Guo, Chen et al. 2004). Lastly, cleaner production approach offers more comprehensive solution than simple pollution control which beneficial for environment, improved the health and living standards while creating a safer environment for all species.

2.8.2 Barrier and Drivers on Adapting CP Concept

CP concept as environmental prevention strategy beneficial in term of reducing the adverse effects on environment and humans. However, some difficulties will be faced on implementation of CP concept if the problems were not carefully identified (Dieleman, 2007). Poor understanding in spotting the challenge will cause the CP adaption process to be less effective or failed. This will not only lead to negative consequences in managing environmental issue, but also influence the manufacturing sustainability performance by the manufacture.

Economic performance is identified as an important role for the implementation of CP concept. High investment cost is commonly required at the early stage, but CP option has proved successful economic beneficial in long term operation (Hicks & Dietmar, 2007). This is usually happening when manufacturers are requires investing new equipment or machinery that more environmentally friendly and labor in compliance with new environmental standard. However, small and medium-sized enterprises (SMEs) recognized it as major challenges because of limited available financial resources (Hoof & Lyon, 2013). Without sufficient resources and good economic performance, manufacturer will encounter difficulty in adapting the relevant changes and lead to the implementation of CP system cannot be fully realized. Besides, manufacturers are still comfortable with the utilization of conventional pollution prevention system such as end-of-pipe in managing environmental issues. This is due to the end-of-pipe system only requires small investment, less changes and development disruption towards existing facilities and current manufacturing process as compared to CP system.

Implementation of CP system is also influenced by the degree of psychological concern. The behavior, culture, mindset, and function of employee and employer significantly affect the performance of psychological concern in implementing CP system, The reason for this is it will have a direct impact on the decision on handling environmental issues, especially during the sharing information within the organization on promotion of green technologies innovation (Yusup et al., 2013). Conversely, organization lack of psychological concern will be resulted low awareness over the environmental issue, that might cause by lack of understanding and knowledge about CP concept, resulted difficulty on adaption of CP system. According to study conducted by Andrews et al. (2002), nearly 49% of SMEs did not share their knowledge and experience in the implementation of CP. Lack of resources and analytical skill, limited technical information and poor knowledge are among the major challenges requires to resolve prior adaption of CP concept. Therefore, inability to overcome this challenge will lead to conflict situation where manufacturers had to choose either to prioritize handling the environmental problems through implementation of CP concept, or focusing in fulfilling their business goals (Seroka-Stolka & Lukomska-Szarek, 2016).

The awareness and participation of all individuals in the organization is the key for improvement in handling environmental issues sustainably and increase the successful rate on adaption the CP strategy. Lack of sensitivity in organization and low commitment from the employees over environmental issues will decrease the responsiveness on adaption CP strategy. This is due to the employee's involvement is closely related to performance of environmental management, especially in encouraging the innovation process and enhance the momentum on improving current system with CP system.

Table 2.3 Summary of Driver and Barriers on Adapting CP Concept

Drivers	Barriers
Reducing Operating Cost	Hesitate to change
Reduction of Ecological Damage	Impression of CP will cost more than existing technologies
Improved Company Image	Uncertainty on acceptance
Reduction of Civil and Criminal Liability	Lower in priority compared to another project

2.9 Environmental innovation

Environmental innovation defined as the execution and modifications of an organization focusing on the environment aspect, with alteration of manufacturing process, products, and marketing, with different degrees of innovation (Dias Angelo et al., 2012; Seroka-Stolka & Lukomska-Szarek, 2016).

There of two different types of environmental innovation that are commonly used to mitigate the environmental impacts of production which are end-of-pipe technologies and cleaner production. End-of-pipe treatments are technique where the removal of contaminants only happened at the last stage of process where the stream is delivered or disposal. The most common end-of-pipe treatment is the catalytic convertors on our automobile tailpipes that reduce the emission of pollutants after they have formed.

Clean production (CP) known as a strategy that used to reduces the environmental impact and consumption of resources while maximizing the output. A better comparison between CP and end-of-pipe technologies had been tabulated in Table 2.4. Cleaner production reduces resources and pollution with the adaption of cleaner product and production methods in the production process, whereas end-of-pipe technologies control the pollutants emissions by implementing add-on measure on current process. (Frondel et al., 2004)

Table 2.4 Comparison between CP and End of Pipe Technologies

End of Pipe	**Cleaner Production**
Handling Pollutants	
Pollution controlled by installing filters and relevant treatment method	Pollution is prevented through measures at the source
Main objective to fulfil standards set by authority	Continuous work to achieve higher and sustainability standard

Table 2.5, continued: Comparison between CP and End of Pipe Technologies

End of Pipe	Cleaner Production
Environmental Control	
Starts when problem arise	Integrated in product and process development
Wastes cost extra money	Waste is potential resources
Technical improvement to existing technologies	Involves of technology and management approaches
Responsibilities	
Improvement addressed only by environmental experts	Involvement of all individuals in the company
Focus	
One-off solution of individual problems	Continuous innovation and evaluation of process
Quality is defined as meeting customer and legal requirements	Goal is to achieve customers' needs with minimal impact on health and environment.

2.10 Summary of Literature Review

At the beginning of the literature review, background of hawker and the operation of hawker centre was discussed. The operation involves fuel, water and electricity consumption, and generation of waste. However, the major environmental issues in the hawker centre are the generation of food waste and plastic usage. Therefore, further study was conducted to identify the impact of it to the environment. Besides from the environmental issues, the risk of foodborne disease was also studied. This is to allow easier identification of potential source of foodborne disease during performing audit analysis.

The second part of the literature review concerned on the climate change and global warming. The effects and causes of global warming were identified which is due to the greenhouse emissions. Carbon footprint is expressed and defined as the global warming potential (GWP) of the greenhouse gases released to the environment during lifecycle of products. Global warming potential is the measurement of heat that is retained in the atmosphere with a certain gas relative to the amount of heat trapped by carbon dioxide. Carbon footprint on food selection was studied to identify how does the type of food affecting the emission of carbon footprint. A general initiative on reducing the carbon emission at food service sector was studied. This allowed proper cleaner production option being generated for this research project. A case study was also performed at Rifrullo Café. This case study provides an insight of the greener initiative towards sustainable development.

The last part of the literature review focus on the cleaner production. Definition and principles of cleaner production was identified. Significance, barriers, and drivers of cleaner production was also identified to understand the acceptance of cleaner production theory in the market. Lastly, environmental innovation such as end of pipe treatment and cleaner production was compared to identify the differences between it.

CHAPTER 3:METHODOLOGY

3.1 Introduction

In this chapter, the specific technique used to conduct the research project will be discussed. Besides, the method on obtaining the requires data, processed, and analyzed to accomplish the stated objective at Chapter 1. The analyzed data will be interpreted and discussed in the following chapter.

The planning of this research project was initiated by identifying the problem statement which used to ensure effective progress of study. Besides, literature review was conducted to identify the possible research gaps in the study and familiarize with related topic. The scope and objectives were set to obtain the desired output. Cleaner production audit was performed at the selected hawker centre to identify the key area where the cleaner production is probable, in order to achieve the aim of this research project which is producing a greener operation at hawker centre by reducing the waste produced and ensure the efficient consumption of energy. The main aspects in the methodology are highlighted as below:

i. Premise selection and site visit to hawker centre.
ii. Conduction of interview to food vendor to identify the overall operation situation and safety issues at hawker centre.
iii. Carrying out CP audit with CP checklist
v. Evaluation of carbon footprint
vi. Identify the possible CP option implementation.
vii. Calculate the Rate of Investment (ROI)

3.2 Overview of Research Methodology

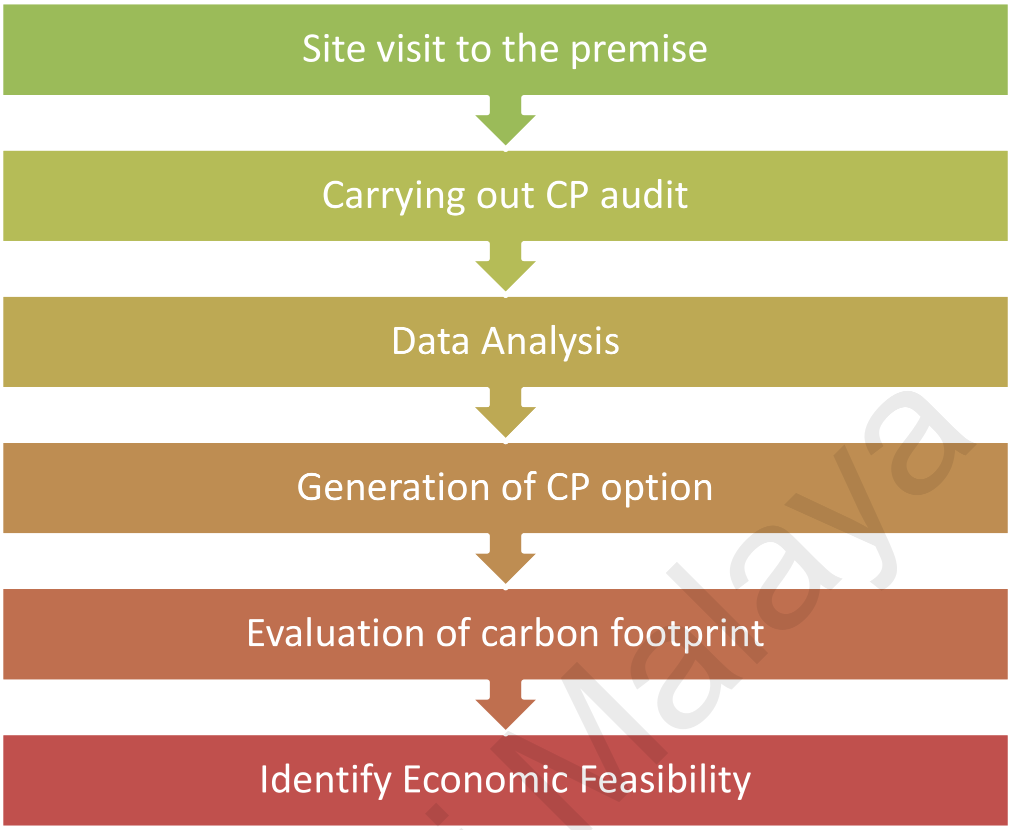

Figure 3.1 Methodology flowchart

3.3 Premise Selection and Site Visit to Premise

To conducting this research project, a hawker centre was selected. Permission was obtained from the hawker centre owner prior conducting the cleaner production audit at the hawker centre premise. Notification of hawker owner through phone call before the research study being conducted. During the preliminary site visit, basic information and identification of basic operation process and facilities locates in the premise was collected. Basic information such as type of foods selling, identifying the peak and off-peak hours of the hawker centre, operation time of each vendor, the total number of foods can be sold a day and type of electric appliances used at the hawker premise. The information was collected by having informal interview the food vendor and spending hours at hawker centre to observe the people traffic flow.

Table 3.1 Basic information of selected hawker centre

No	Item	Information
1	Premise Name	Happy City Food Centre
2	Location	Kepong, Kuala Lumpur
3	Number of Stalls	49
4	Operation hours	9am – 11pm (26 stalls)
		6pm - 11pm (23 stalls)
5	Structure	Open-air complex

Table 3.2 Process flow for food hawking operations

No	Input	Process	Output
1	Raw Material, Electricity	Receiving of raw material and Storage	
2	Raw Material, Electricity, Water	Batching and Food Preparing	Food waste, solid waste (packaging waste from raw material), wastewater
3	Raw Material, Electricity, Fuel, Water, Cooking Oil	Cooking Process	Used cooking oil, wastewater, solid waste (used bottle and container), Product
4	Packaging plastic	Packaging	Solid waste (rejected plastic bag, food container and plastic utensils)
5	Cleaning agents, Electricity, water	Cleaning	Wastewater

3.4 Cleaner Production Audit

It is relatively important to plan and develop audit prior the conduction of cleaner production audit. This is to ensure effective and efficient cleaner production audit can be done. CP audit checklist is prepared as the initiation on CP audit. The main objective of the CP audit is to obtain the quantitative and qualitative information on the operation of hawker premise. The audit checklist includes the following aspect:

i. Information on energy and resource consumption and waste generation
ii. Information on type, quantities and source of waste generated
iii. Identify the potential hazards in the hawker premise

Interview was also performed with food vendor to identify the food materials requires by reviewing their raw material purchases, information of food handling and waste management practice in the hawker premise, informAnaFoation on accident history in the hawker premise. There are three types of hawker food that are selected to identify the food waste during the food preparing and handling process. The selected hawker food will be chicken chop rice, noodle soup and wanton mee, the reason of selection is because it is commonly available at all hawkers.

3.5 Data Analysis

From the data collected from walkthrough observation, CP audit and interview, data analysis was performed to identify the suitable CP implementation in the necessary aspect. The CP option generated will consider the safety of worker and environmental beneficial. Carbon footprint will be calculated before and after the implementation of CP option to ensure the effectiveness of CP option.

3.6 Carbon dioxide emission factor

Carbon footprint is a tool used to measure and estimate the impact of human activities affecting the climate change. The units of carbon footprint are usually expressed in terms of CO_2 equivalent. The calculation of carbon footprint can be calculated with the formula listed.

$$GHG\ (kg\ CO_2eq) = aspect\ quantity\ data\ x\ global\ warming\ potential$$

A quantity of GHG can be expressed as CO_{2eq} by multiplying the amount of the GHG by its GWP. As example, if 1kg of methane is emitted, this can be expressed as 25kg of CO_{2eq} (1kg CH_4 * 25 = 25kg CO_{2eq}).

Table 3.3 GWP over 100 years' time horizon

Greenhouse Gasses	Chemical Formula	Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	NO_2	298

For the CO_2 emission factor of different type only the main ingredient of the dishes is considered during the carbon footprint calculation. The CO_2 emission factor obtained only account for the production emission and may not include the additional emissions from the usage of farm equipment's, animal feeds processing and package waste during the production process.

Table 3.4 CO_2 emission factor for the main material used in preparing Chicken Chop Rice

Type A: Chicken Chop Rice		
Material	**CO_2 Emission Factor (kg CO_2/kg)**	**Reference**
Chicken	6.90	(HEALable, 2021)
Cooking Oil	3.89	
Rice	2.70	
Flour	0.62	
Cucumber	0.14	
Potatoes	2.90	
Water	0.32	

Table 3.5 CO_2 emission factor for the main material used in Wanton Noodle

Type B: Wanton Noodle		
Material	**CO_2 Emission Factor (kg CO_2/kg)**	**Reference**
Vegetable	1.60	(HEALable, 2021)
Chair Siew (pork)	12.10	
Pork	12.10	
Flour	0.62	
Egg	4.80	
Water	0.32	
Oil	3.89	
Soy Sauce	2.00	
Noodle	1.24	

Table 3.6 CO_2 emission factor for the main material used in preparing Chicken Noodle Soup

Type B: Chicken Noodle Soup		
Material	**CO_2 Emission Factor (kg CO_2/kg)**	**Reference**
Noodle	1.24	(HEALable, 2021)
Vegetables	1.60	
Water	0.32	
Chicken	6.90	

Table 3.7 CO_2 emission factor for the resources and waste produced

Material	CO_2 Emission Factor	Unit	Reference
Water	0.80	kg CO_2/m^3	(Cornejo et al., 2014)
Electricity	0.67	kg CO_2/kWh	(Association of Water & Energy Research Malaysia, 2012)
Fuel - LPG	1.53	kg CO_2/liter	(Change, 2006)
Solid Waste	3.70	kg CO_2/kg	(Murphy & McKeogh, 2004)
Food Waste	2.00	kg CO_2/kg	(Monier et al., 2010)
Wastewater	1.00	kg CO_2/kg COD (removed)	(Keller & Hartley, 2003)

3.7 Calculation of Payback Period and Return of Investment

Payback period is defined as the duration required to recover the cost of investment and it is commonly used to determine the economic feasibility of the investment. The shorter the payback period of the investment, the sooner the recovery of investment cost. In this study, the economic feasibility of the generated CP options was calculated by estimation of investment cost and determination of expected savings with the CP option adoption. The formula used in estimation of payback period is:

$$Payback\ Period = \frac{Total\ Project\ Cost}{Total\ Annual\ Saving}$$

3.8 General Safety Adopted during Study

A walkthrough inspection and interview are conducted to observe and obtained the required data from the beginning to end of the operation which includes the raw material, energy and water consumption and the waste generated from the production process. The interview session with the food vendors are during the off-peak hour, this is to ensure that the food vendors are not distracted and prevention on accident occurs. During this covid-19 pandemic, the standard operating procedure was followed, and face mask was worn and maintaining proper social distance at the hawker premise. Besides, extra precaution was given when near to the fire source during the audit inspection.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Audit Analysis

Cleaner Production was carried out at the selected hawker premise which located at Kepong as planned. The hawker centre selected is a non-halal eatery; it operates from 9am to 12am daily with a total of 49 stalls and 98 people involved in the daily operation. 98 people includes the food vendor and cleaner working at the hawker centre. From the observation and interview among the workers, there are a total of two sessions of peak hour period at this hawker centre which are 12pm to 2.00pm and 6pm to 9pm. As this research project was carried during the Covid-19 pandemic and dine-in was banned during the lockdown, therefore insufficient information on dine-in customer was collected. From the recorded data form the hawker centre owner and the customer counting performed at the hawker centre for 2 weeks' time to obtain the consistent pattern of the hawker operation, there are approximately 2,956 customers visiting this hawker centre daily for takeaways order. As this hawker centre had joined the online platform for food ordering, there are average of 328 orders daily from the online food delivery service platform. Therefore, a total of customer 3,284 customer daily.

At the meantime, the sales per stall was also obtained through the order ticket from the hawker vendor, there are average of 130 portions per vendor being sold daily. Assuming the same trend over the month and operation of 26 days with a day off in a week, there will be a total of 85,384 customer and 165,620 portion being sold per month. The average serving size at the hawker centre fall at 550g per serving. Whereas for the case of meal production, the average production was found to be 140 portion per vendor daily. Process flow, resources consumption, operation practice and waste generation were identified during the CP audit. The details of audit findings are summarized and listen in Appendix A. The annual energy and resources consumption on annual basis had summarized in Table 4.1 and the annual operation cost for the overall hawker centre will be RM 356,378.08 and total cost annual cost per vendor will be RM 7,315.52.

Table 4.1 Energy Consumption at hawker centre on annual basis

Resource	**Electricity (kWh)**	**Water (m^3)**	**Fuel – LPG (kg)**
Annual Consumption(unit)	196,018.20	14,460.00	117,600.00
Unit Cost (RM/unit)	0.51	2.28	1.90
Annual Cost (RM)	99,969.28	32,968.80	223,440.00
Annual Cost per Vendor (RM)	2,082.69	672.83	4,560.00

Table 4.2 Daily Weight of Produced, Distributed and Leftover meal

Item	**Average amount**
Produced meal	3,773.00 kg
Distributed meal	3503.50 kg
Leftover	269.50 kg
Food scrap	764.40 kg
Rotten Food / Expired Meal	66.60kg

4.1.1 Fuel Consumption

Liquefied petroleum gas (LPG) was used as the source of fuel for cooking and heating process. The LPG used was calculated based on the monthly purchase record of the LPG gas tank. The LPG fuel for restaurant was purchased at the price of 1.90 MYR/kg. The LPG gas that used in the hawker centre is 14 kg in size and a monthly usage of 700 tanks which equivalent to 9,800 kg of LPG fuel was required to maintain the normal operation of hawker centre. Thus, the monthly cost on the LPG fuel will be RM 18,620.

4.1.2 Electricity Consumption

Based on the audit findings, electricity consumption accounts for the highest operation cost in hawker centre. Quantification of electricity usage in this study was determined based on the monthly electric bill received. According to the electricity consumption calculated based on the main electrical appliance unit which commonly found from at hawker centre, the electricity consumption is 16,334.85 kWh. The calculated cost is based on TNB tariff rates, Tariff B - Low Voltage Commercial Tariff, the first 200 kWh unit of electricity was purchased at the 0.435 MYR/unit and 0.509 MYR/unit for electricity the consumption of 200 kWh onwards. The monthly electricity consumption of the hawker centre is RM 8,299.64. There are 49 individual hawker stall locates in the hawker centre and the cost for each stall will be RM 169.38. Table 4.2 present the energy rating and operating hours of main electrical appliance. From Table 4.2, chiller and freezer that used for storage of food material accounts for the highest electricity usage, thus more CP option should be generated targeting the usage of chiller and freezer.

Table 4.3 Electricity consumption of different appliance at hawker centre

No	Type of Appliance	Power (kW)	Operating hours/month	Monthly consumption per unit (kWh/month)	Total unit	Total Monthly Consumption (kWh/month)
1	Fluorescent light	0.043	390	16.77	65	1090.05
2	Wall fan	0.180	390	70.20	16	1123.20
3	Ceiling fan	0.165	390	64.35	18	1158.30
4	Exhaust fan	0.110	390	42.90	10	429.00
5	32" LCD Television	0.070	390	27.30	8	218.40
5	3-Door Display Chiller	1.045	720	752.40	5	3762.00
6	Single Door Display Chiller	0.735	720	529.20	4	2116.80
7	4-Door Upright Freezer	0.980	720	705.60	6	4233.60
8	Kitchen Blender	0.400	234	93.60	5	468.00
9	Juicer	0.950	234	222.30	5	1111.50
10	Toaster Oven	1.200	234	156.00	4	624.00
					Total Monthly Electricity Usage (kWh/month)	**16,334.85**
					Total Annual Electricity Usage (kWh/month)	**196,018.20**

4.1.3 Water Consumption

According to the audit finding, it shows that the water is essential element in the operation of hawker centre. Water is used during the food preparation, food processing, cleaning, and it also the main ingredient used in preparation of beverage. From the audit finding, there are average of 140 portions of meals being prepared by the hawker vendor and therefore it is a useful information for the calculation of water used in food. The total water usage at the hawker centre was 1205 m^3 and water was purchased at the rate of RM RM2.28/m^3 which translated into RM 2747.40 per month. Food preparing process includes the pre-rinse and cleaning of food material requires at the following process, a total of 144.68m^3 was used. For the food processing where the actual cooking process requires 304,000 kg of water to produce 98,098 kg of food monthly, if 140 serving prepared and average serving size was 550g per food vendor was used. However, the usage of water depends on the type of dishes, noodles usually require more water than rice dishes. The cleaning process which includes the dish washes and floor cleaning before and after operation of the hawker centre. Water usage for domestic purpose will be around 204m^3. Table 4.3 had summarized the overall water consumption used in the premise.

Table 4.4 Analysis of water consumption in the hawker centre per month

Water End Use	Water Consumption per month (m^3)
Food Preparing	145
Food Processing	304
Cleaning Process	552
Domestic Usage	204
Total Monthly Usage	1205
Total Annual Usage	14,460

4.1.4 Food Material for selected dishes

The hawker selected comprise of 49 individual hawker vendor preparing various kind of dishes to cater the needs of customer. With the various kind of dishes being sold, it is hard to identify the actual food material being used in the whole hawker centre operation. However, to identify the carbon footprint and comparing the carbon footprint emission between dishes, chicken chop rice, Wanton noodle and chicken soup noodle which labeled with Type A, B and C respectively, was being selected for the comparison. The selection of these 3 dishes is because it is commonly found across the hawker centre in Malaysia and the food vendor had proper recording keeping on the raw material usage. The raw material only considers the main ingredients of the dishes. During the auditing process, the receiving of raw material, storage, preparing and cooking and packing area was identified as the key process contribute to the raw material losses. During the food preparing process, inedible part of the raw food material such as potato peels and eggshells are generated and contribute to the raw material lost. Besides, cooking process will contribute to the weight lost for meat and vegetables due to shrinkage whereas dry good such as noodle and rice will absorb water which led to increase in weight after cooking.

Table 4.5 Analysis of the Production of Type A dish

Type A: Chicken Chop Rice (for 120plates)							
Weight of Raw Material Used (kg)		Weight of Food Waste Generated (kg)		Weight of Food Produced (kg)		Weight of leftover food due to overpreparation (kg)	
Chicken	30.00	Fat from Chicken	4.00	Chicken	25.00	Chicken	1.00
Potatoes	15.00	Vegetable Peels	3.00	Rice	34.00	Rice	2.00
Cucumber	5.00	Rice Sticking on Pot	2.00	Potato Wedges	12.50	Potato Wedges	0.50
Dry Rice	12.00	Burnt Food	1.50	Cucumber	4.50	Cucumber	0.50
Water	15.00	Used Cooking Oil	3.50				
Flour	5.00	Overpreparation	4.00				
Oil	4.00						
Total Raw Material Used (kg)	86.00	Total Waste Produce (kg)	10.50	Total Weight Produced (kg)	76.00	Total Leftover (kg)	4.00
Total Material Used Per Serving (kg)	0.72	Total Waste Produced Per Serving (kg)	0.09	Total Weight Produced per serving (kg)	0.63	Total Leftover per serving (kg)	0.03

Table 4.6 Analysis of the Production of Type B dish

Type B: Wanton Noodle (for 200 plates)							
Weight of Raw Material Used (kg)		Weight of Food Waste Generated (kg)		Weight of Food Produced		Weight of leftover food due to overpreparation (kg)	
Vegetable	15.00	Egg shell	0.10	Char Siew	22.00	Char Siew	2.00
Pre-cooked Char Siew	25.00	Excess Fat	3.00	Wanton	13.00	Vegetables	1.00
Pork	8.00	Overcooked food	6.00	Noodle	60.00		
Flour	3.00	Noodle Water	15.00	Vegetables	10.00		
Egg	0.60	Vegetable Waste	2.00				
Water	51.50	Overpreparation	3.00				
Oil	1.00						
Soy Sauce	2.00						
Noodle	25.00						
Total Raw Material Used (kg)	131.10	Total Waste Produce (kg)	29.10	Total Weight Produced (kg)	105.00	Total Leftover (kg)	3.00
Total Material Used Per Serving (kg)	0.66	Total Waste Produced Per Serving (kg)	0.15	Total Weight Produced per serving (kg)	0.53	Total Leftover per serving (kg)	0.02

Table 4.7 Analysis of the Production of Type C dish

Type C: Chicken Noodle Soup (for 100 bowls)							
Weight of Raw Material Used (kg)		Weight of Food Waste Generated (kg)		Weight of Food Produced (kg)		Weight of leftover food due to overpreparation (kg)	
Vegetable	12.00	Fat and Bones from Chicken	3.50	Noodle	30.00	Vegetable	2.00
Chicken	15.00	Vegetable Peels	2.00	Vegetable	6.00	Soup	5.00
Water	80.00	Leftover in the pot	3.00	Soup	35.00		
Noodle	15.00	Noodle water	10.00				
		Overpreparation	7.00				
Total Raw Material Used (kg)	122.00	Total Waste Produce (kg)	25.50	Total Weight Produced (kg)	81.00	Total Leftover (kg)	7.00
Total Material Used Per Serving (kg)	1.22	Total Waste Produced Per Serving (kg)	0.26	Total Weight Produced per serving (kg)	0.81	Total Leftover per serving (kg)	0.07

4.1.5 Waste Generation

According to the audits finding, it shown that the wastes generated in the hawker centre were divided into four groups which are, solid waste, food waste, hazardous waste, and wastewater. All the solid waste generated at the hawker centre was thrown to the bin provided by DBKL which will be collected daily whereas, liquid waste will be thrown through the sink during cleaning. Table 4.8 summarized the monthly waste production and their respective quantities.

Table 4.8 Waste produced at hawker centre per month

Type	Waste Generation Monthly
Food Waste	26,881 kg
Used Cooking Oil	252 kg
Solid Waste	1,442 kg
Hazardous waste	3,500 kg
Wastewater	901 m^3

The audit finding had shown that the monthly food waste generated at the hawker centre is about 26,881 kg per month. The food wastes consider the leftover and food scrap such as vegetable peels, burnt food, bones, etc. There were 252 kg of cooking oil being generated. The generation of used cooking oil was relatively low as hawker vendor because it was observed that the cooking oil was used for many days before being changed.

For the case of wastewater, there were a total of 901m^3 of wastewater being generated per month. Food preparation such pre-rinse and washing of vegetable, cleaning and domestic usage are the source of wastewater. According to research conduct by Chen et al. (2000), the discharged COD value of Chinese restaurant ranges from 292 mg/l to 3390 mg/l. Therefore, COD value of 1,841 was considered.

For the case of solid waste, a total of 1,422 kg was generated, and it mainly comprise of paper, cardboard, plastic, and seal tape. Based on the Appendix A, Part 5: Solid Waste Quantification, plastic accounts for the highest solid waste followed by cardboard, paper and lastly, seal tape. All these items were the common item that used for packaging. Any liquid, solid, or gaseous with the characteristic of poisonous, corrosive, flammable or chemical reactive are classified as hazardous waste. Hazardous waste that found at the hawker centre was summarized in Table 4.9

Table 4.9 Hazardous waste present at hawker centre

No	Hazardous Waste
1	Fluorescent lightbulbs
2	Batteries
3	Bleach used for cleaning
4	Fuel Gas Cylinder (LPG)
5	Rotten and expired food
6	Pesticide used for pest control
7	Lubricants, glues, and paints used to upkeep hawker centre
8	Residue of concentrated cleaner in the container
9	Drain and dish cleaners

4.1.6 Risk and Safety Issues

The potential safety issues at the hawker centre were identified through observation and performing informal interviews between the hawker vendor to obtain the information of previous accident happened.

Table 4.10 List of Safety Issue Observed at Hawker Centre

No	Safety Issue	Risk
1	Slippery floor due to the oil and grease from the cooking process	Slip, trip and falls
2	Hot surface for area near the stove	Burn Skin
3	No proper place to keep sharp object such as knifes.	Cut and injuries
4	Dull blade	Cut and injuries
5	Water overflow at sink of beverage counter	Slip and falls
6	Dirty dishes and bowls are collected and then dumped in plastic containers filled with soapy water hours before they are washed and reused	Foodborne disease
7	Gas leaking from LPG tank	Fire and Explosion
8	Uneven and deteriorated floor surfaces	Slip, trip, and falls

From Table 4.10, it summarized the risk and safety issues that might encounter during the operation of hawker centre. According to the hawker vendor, the risk of fall and slip was most happened. The risk of slipping sometimes brought the risk of burning as there are a lot of hot surfaces at each cooking station and vendor requires to serve the customer which led to risk of splashing hot soup when slip.

4.2 Carbon Footprint Estimation

Calculation of carbon footprint was carried out to identify the total carbon dioxide emission to the environment. The total CO_2 emission was calculated based on the energy and water consumption and the waste generated such as solid waste, wastewater, and food waste at the hawker centre. The estimated carbon footprint produced from the hawker premise was 101,390.27 $kgCO_2$ which equivalent to 1171.76 tons monthly, which equals to 1.18 $kgCO_2$ per customer visited the hawker centre. The carbon footprint calculation for respective element is listed below and the calculated estimation was tabulated in Table 4.11.

For Electricity Consumption,

Consumption of electricity per month = 16,334.85 kWh

Estimated carbon footprint = 16,334.85 kWh × 0.67 kg CO_2/kWh = 10,944.35 kg CO_2

$$\text{Estimated carbon footprint per } customer = \frac{10{,}944.35\ kg\ CO_2}{85{,}384} = 0.13\ kg\ CO_2$$

For Water Consumption,

Consumption of water per month = 1,442.00 m^3

Estimated carbon footprint = 1,442.00 m^3 × 0.80 kg CO_2/m^3 = 1,153.60 kg CO_2

$$\text{Estimated carbon footprint per customer} = \frac{1{,}153.60\ \text{kg CO}_2}{85{,}384} = 0.01\ \text{kg CO}_2$$

For Fuel Consumption (LPG),

Consumption of LPG per month = 9,800.00 kg = 18,667.00 liters

Estimated carbon footprint = 18,667.00 liters × 1.53 kg CO_2/liters = 28,560.51 kg CO_2

$$\text{Estimated carbon footprint per customer} = \frac{28{,}560.51\ \text{kg CO}_2}{85{,}384} = 0.33\ \text{kg CO}_2$$

For Generation of Food Waste,

Generation of food waste per month = 26,881.00 kg

Estimated carbon footprint = 26,881 kg × 2 kg CO_2/kg= 53,762.00 kg CO_2

$$\text{Estimated carbon footprint per customer} = \frac{53{,}762\ \text{kg CO}_2}{85{,}384} = 0.63\ \text{kg CO}_2$$

For Generation of Solid Waste,

Generation of food waste per month = 1,442 kg

Estimated carbon footprint = 1,442 kg × 3.7 kg CO_2/kg= 5,335.40 kg CO_2

$$\text{Estimated carbon footprint per customer} = \frac{5{,}335.40 \text{ kg CO}_2}{85{,}384} = 0.06 \text{ kg CO}_2$$

For Generation of Wastewater,

Generation of food waste per month = 901 m^3

COD value = 1,814 mg/L

$$\text{Estimated carbon footprint} = \frac{901 \text{ m}^3 \times 1000 \times \frac{1{,}814\text{mg}}{\text{L}} \times 1 \frac{\text{kg CO}_2}{\text{kg COD removed}}}{1{,}000{,}000}$$

$$= 1{,}634.41 \text{ kg CO}_2$$

$$\text{Estimated carbon footprint per customer} = \frac{1{,}634.41 \text{ kg CO}_2}{85{,}384} = 0.02 \text{ kg CO}_2$$

Table 4.11 Carbon dioxide emission on monthly basis

Item	CO_2 emission kg / month ($kgCO_2$ / month)	kg CO_2 per customer
15,574.35 kWh electricity	10,944.35	0.13
1,442 m^3 water	1,153.60	0.01
18,667 liters LPG	28,560.51	0.33
26,881 kg food waste	53,762.00	0.63
1,442 kg solid waste	5,335.40	0.06
901 m^3 wastewater	1,634.41	0.02
Total	**101,390.27**	**1.18**

Aside from the CO_2 emission from the operation of hawker centre, the carbon emission from the selected food types is also calculated. However, the calculation performed only depends on the main ingredient involved with their respective weight used during the preparation. Factors affecting the carbon footprint release during cooking process such as type of cooking and change of mass during cooking were not considered. This is because lack of literature study on this field and every aspect will affect the carbon footprint emission. Type A is fried chicken chop rice, the cooking method was frying, whereas for Type B is wanton noodle and Type C is chicken soup noodle the cooking method involved will be boiling.

Table 4.12 Carbon Footprint estimation for Type A dish (Chicken Chop Rice)

Raw Material	Weight (kg)	CO_2 Emission Factor ($kgCO_2$ / kg)	Estimated carbon footprint ($kgCO_2$)
Chicken	30.00	6.90	207.00
Potatoes	15.00	2.90	43.50
Cucumber	5.00	0.14	0.70
Dry Rice	12.00	2.70	32.40
Water	15.00	0.32	4.80
Flour	5.00	0.62	3.10
Oil	4.00	3.89	15.56
Total CO_2 emission (120 servings)			307.06
Total CO_2 emission per serving (0.63 kg per serving)			2.56
Total CO_2 emission per kg of food produced			3.79

Table 4.13 Carbon Footprint estimation for Type B dish (Wanton Noodle)

Raw Material	Weight	CO_2 Emission Factor ($kgCO_2$ / kg)	Estimated carbon footprint ($kgCO_2$)
Vegetable	15.00	1.60	24.00
Pre-cooked Chair Siew	25.00	12.10	302.50
Pork	8.00	12.10	96.8
Flour	3.00	0.62	1.86
Egg	0.60	4.80	2.88
Water	51.50	0.32	16.48
Oil	1.00	3.89	3.89
Soy Sauce	2.00	2.00	4.00
Noodle	25.00	1.24	31.00
Total CO_2 emission (200 servings)			483.41
Total CO_2 emission per serving (0.53 kg per serving)			2.42
Total CO_2 emission per kg of food produced			4.56

Table 4.14 Carbon Footprint estimation for Type C dish (Chicken Soup Noodle)

Raw Material	Weight	CO_2 Emission Factor ($kgCO_2$ / kg)	Estimated carbon footprint ($kgCO_2$)
Vegetable	12 kg	1.60	19.2
Chicken	15 kg	6.90	103.5
Water	80 kg	0.32	25.6
Noodle	15 kg	1.24	18.6
Total CO_2 emission (100 servings)			166.9
Total CO_2 emission per serving (0.81 kg per serving)			1.67
Total CO_2 emission per kg of food produced			2.06

According to the calculation performed, Type A dish release the most 2.56 kg_CO_2 followed by Type B with 2.42 kg CO_2 and lastly Type C only released 1.67 kg CO_2 per serving. By comparing Type A and Type C dishes, it was observed that frying process will contribute more the carbon emission due the oil usage. Therefore, changing the method of cooking such as by replacing frying process with roasting. Even though, Type B dish did not involve frying process, but the carbon emission is relatively high. This is because there was more meat being served for Type B dish. By referring the carbon emission factor, meat will be releasing more carbon compared to vegetables. Therefore, it was suggested for increase the usage of vegetable to achieve some nutritional value. For such examples, replacing meat with tofu to achieve the daily protein intake. Thus, for a consumer to reduce the carbon footprint emission, it will be suggested reducing the meat consumption and choosing the method of cooking that uses less oil.

4.3 Generation of CP Options

Accordance to the analysis of audit findings, CP options were generated to reduce the carbon footprint generated and improve the efficiency and safety of the hawker centre. Cleaner production promotes the efficient use of current resources at the meantime reducing the waste and pollutions being generated.

4.3.1 CP options on Reduction of Electricity Consumption

From the previous carbon footprint estimation, it was found that electricity was the contributor of carbon footprint at the hawker centre. Therefore, a series of CP options was generated to reduce the electricity usage at the hawker centre as well as reducing the carbon emission.

CP Option 1 (Rearrangement of hawker vendor position)

The operation of hawker vendor had split into 2 section which are from 9am to 12am and 6pm to 12am. By arranging the hawker vendor operates from the morning to the same zone, usage of fan and lightning can be reduced up to 20% from the current operation which equivalent to 737.38 kWh per month and 494.04 kg CO_2 emission.

Calculation for 20% reduction on fan and lightning:

For light:

Total Monthly Consumption = 1090.05 kWh

Saving Per month = 0.20 (1090.05 kWh) = 218.01 kWh

For Wall Fan,

Total Monthly Consumption = 1123.20 kWh

Saving per month = 0.20 (1123.20 kWh) = 224.64 kWh

For Ceiling Fan,

Total Monthly Consumption = 1158.30 kWh

Saving per month = 0.20 (1158.30 kWh) = 231.66 kWh

Total Saving per month = (281.08 + 224.64 + 231.66) kWh = 737.38 kWh

Total carbon footprint reduction = 737.38 kWh × 0.67 CO_2/ kWh = 494.04 kgCO_2

CP Option 2 (Switched off unnecessary)

There are total of 8 televisions at the hawker centre, during the audit walkthrough, it was observed that the television was switched on even there are no customer or food vendor watching it. By operating the television only at peak hour, equivalents of 5 hours per day reduces 145.6 kWh per month which lead to 97.6 kgCO_2 reduction.

CP Option 3 (Switched off light)

Besides, the hawker centre is an open-air complex, natural light can be used as the source of lighting during the day times. This option can be implemented immediately as there are no investment cost requires and it significantly decrease the usage of lightning 140.4kWh per month and 94 kgCO_2.

CP Option 4: (Usage of LED light)

From the audit analysis, it was found that there are total of 65 fluorescent lights which installed at the hawker center. Therefore, fluorescent light is the main lightning system installed at the hawker centre. Compared to the current technology, LED lighting is more energy efficient than fluorescent tube. LED light co nsume up to 80% less energy than incandescent and 40% less energy consumption than most fluorescent light (Ganandran et al., 2014). By switching the fluorescent light to LED light, a total 436.02kWh of electric usage can be reduces which contribute to 292.13 kgCO_2 reduction monthly. The payback period for switching 65 fluorescent lights to LED lights was calculated as below:

Investment cost: RM 1,950.00

Annual Saving = RM 2,663.20

Payback Period = Investment cost/ Annual Saving = 9 months

CP Option 5 (Invest in Energy Saving Appliances)

Chiller used in the hawker centre are energy intensive as accordance to the hawker owner the display chiller was either brought secondhand without considering the power consumption. During the audit analysis, it was found that display chiller was used by some hawker vendor to store their raw food material. It was suggested to replace the unit of 3 door-display chiller being used for storage of raw food material to 6-door upright chiller as it helps to conserve energy. This is due to the 3-door display chiller consume 752.4kWh/ month whereas 6-door upright chiller only consume 403.2 kWh/month. The total CO_2 emission reduction will be 234kg CO_2 per month. The payback period was calculated as below.

Figure 4.1 6-door upright chiller

Investment Cost = RM5,790

Annual Saving = RM 2,105

Payback Period = Investment cost/ Annual Cost = 2 years 9 months

CP Option 6 (Maintenance of Freezer)

Ensure the freezer was well-maintained, where the radiator behind the freezer was dust regularly and ensure the condition of door seals that they are perfectly sealed. Freezer must be defrosted once a year or as often the ice built up. 10% more energy will be consumed with every 2mm mean of ice buildup. Therefore, with a good maintenance of freezer can avoid the 423.36 kWh/month and 284kg CO_2 being generated.

CP Option 7 (Installation of Movement Sensor)

Restrooms in hawker centre was share among the customer and hawker vendor, therefore it was hard to ensure the light was closed. With the installation of movement sensor in the restroom can ensure the light was turned off when the restroom left vacant. Therefore, this option can reduce electricity consumption by 5% which is about reduction of 22 kg CO_2.

Electricity consumption affects the environment significantly due to the emission production of greenhouse gases. According to the Ganandran et al. (2014), combustion of fossil fuel produced to up to 80% of world electricity and greenhouse gases will be produced during the combustion of fossil fuel. To reduces the environmental impact, contribute by electricity consumption, a total of 7 cleaner production was generated.

4.3.2 CP options on Reduction of Water Consumption

Water is the major element for the normal operation of hawker centre. Water in hawker centre is requires in preparation, processing, cleaning, and even domestic usage. According to the carbon footprint quantifications, usage of water accounts for 1150 $kgCO_2$ emission per month and cleaning process accounts to the largest usage of water usage. Thus, cleaner production option was generated to reduce the water usage and at the meantime reducing the carbon footprint generated.

CP Option 8 (Installation of Tap Aerator)

Consumption of water can be reduced with the installation of tap aerator. Flow aerator will be installed at the toilets and sinks that used for cleaning process. It was recorded aerator will saved up to 70% of water usage at the faucet and as per estimate use of aerator can save up to 1,274 liters per month. However, faucet at the cooking station will not be installed with the aerator as it will increase the time requires for water filling. Therefore, only faucet used for food preparing, cleaning and toilet were installed water aerator, a total of 60 aerator being installed. A total of 76.44 m^3 of water usage being reduced which contribute to 61.15kg CO_2. The payback period for installation of aerator was calculated below:

Investment Cost = RM 900

Annual Saving = RM 2,091

Payback Period = Investment cost/ Annual Cost = 5 months

CP Option 9 (Reuse of water)

Water used for food preparation such as water used for cleaning the vegetable and washing rice can be collected and be reused. The collected water can be used as cleansing water for washing floor before or after the operation of hawker. This can reduce approximate 10% of water used in cleaning. Therefore, the water usage will be reduced 55.2m^3 monthly and accounts for carbon reduction up to 44.16 kg CO_2.

CP Option 10 (Avoid washing under running tap)

Running tap must be avoided during washing and cleaning. This is because running tap uses 6L of water every minute. Food preparation and cleaning dishes in standing water can save up to 20% of water compared to running tap and larger load can be washed with the equals amount of water used. 115.3m^3 of water can be reduced which equivalent to reduction of 88.32 kg CO_2 per month.

<u>CP Option 11 (Avoid washing under running tap)</u>

To optimize the usage of water during cleaning process, amount of cleaning agents used must be efficient. Over usage of cleaning agent will requires more water to dilute whereas below usage will affect the cleaning duration required which eventually led to higher water usage.

<u>CP Option 12 (Using Dishwasher for dish cleansing)</u>

According to the audit finding, the dishes will be soaked for 20 minutes and washed by cleaner under running tap. This procedure causes dishwashing activities contribute to high water usage on the cleaning part. With the application of dishwasher at the hawker centre, it can save up to 40% of water usage on cleaning compared to washing the dishes under running tap. Thus, a total of 220.80 m^3 of water can be saved monthly which contributes to 176.64 kg CO_2 of carbon footprint reduction per month. Besides from reduction on water usage, dishwasher also helps to ensure smooth operation of hawker centre and cleanliness of the plate and utensils. The payback period of installation a commercial dishwasher at the hawker centre was calculated as below.

Investment Cost = RM 10,000

Annual Saving = RM6,041

Payback Period = Investment cost / Annual cost = 1 year and 8 months

CP Option 13 (Fixture of leaking pipe)

According to Environmental Protection Agency (EPA), every year there are more than 10,000 gallon of water being wasted due to leaking pipe. By fixing the water leaks, a total of 10% can be saved monthly. Thus, an approximate of 120m^3 of water reduction monthly which contribute to 96kg CO_2 of carbon reduction

Climate change is an ongoing issue to the global and we can no longer ignore the happening of it. Hawker industry should take action to promote sustainable gastronomy. Water efficiency and water consumption is one of the key elements in sustainable gastronomy. Therefore, a total of 6 cleaner production option was generated to promote greener hawker activities.

4.3.3 CP options on Reduction of Fuel – LPG Consumption

According to the audit finding, the usage of LPG fuel contributes to the large portion of carbon emission of the hawker centre. Therefore, it is relatively important to generate cleaner production option to reduce the usage of LPG fuel.

CP Option 14 (Using Pressure Cooker)

Improve the efficiency of cooking can reduced the LPG fuel usage at the hawker centre. Usage of pressure cooker during cooking process was recommended as it will reduces the cooking duration ups to 66% and cutting the energy used of 30%

CP Option 15 (Using the Right Amount of Water)

During the audit assessment, it was observed that hawker vendor tends to use the stock pot to cook the noodle. Reducing the size of pot can reduces the water usage and energy usage to boil the water. The larger the volume of water, the longer the time requires for boil which resulted to high fuel usage. This CP option will potentially reduce the water usage and reduces the fuel usage by 15%.

CP Option 16 (Cooking on Low Flame)

Consumption of fuel can be reduced when cooking with low flame, especially for the soup dishes. Turning to low flame after it boils can conserve the fuel usage up to 6%.

CP Option 17 (Switching to Electrical Cooking)

With the advancement in technology, hawker vendor can replace their cooking on stove to electrical cooking such as induction cooker, smart cooker and air fryer. Food that requires frying can be replaced with air fryer as it can reduces the fuel and oil usage. Besides, precooked meal that requires to keep warm can be done with the application of smart cooker instead of warming it on stove. With the application of electrical cooking, it can reduce the fuel consumption and reduce the risk of LPG fuel leak which can cause explosion.

According to the audit finding, LPG fuel is widely use by hawker vendor for the cooking process. However, LPG is a non-renewable energy, and it emits greenhouse gases which will contributes to the climate change. Therefore, a total of 4 cleaner production option was generated to reduce or avoid the fuel usage which contribute to a greener hawker operation.

4.3.4 CP options on Reduction of Food Waste Production

According to the audit finding, the generation of food waste contributes to the largest portion of carbon emission of the hawker centre. Therefore, it is relatively important to generate cleaner production option to reduce or avoid the food waste being generated.

CP Option 18 (Knowing the customer traffic flow pattern)

By identifying the customer traffic flow pattern, the volume requirements of the raw material for the day will be identified. For examples, during the festive season, hawker tends to have a decrease in customer as people tend to dine at restaurant with friends and family. Therefore, the volume of raw material can be decreased to prevent food waste. This CP options will be allowed hawker vendor to reduce the food waste up to 15%.

CP Option 19 (Selling dishes using the same raw material)

During the menu planning, it is relatively important to sell the dishes which shares the same raw material, this can ensure the usage of ingredients and less variety of ingredients being used generates less waste. This CP option can reduce the food waste by 10%

CP Option 20 (Keep the waste log)

Prepare and review the waste log weekly and identify the key ingredients that contribute to the food waste producing. This can help to hawker vendor to reduces the cost and avoid food waste generated.

CP Option 21 (Avoid batches production)

Some of the hawker vendor usually will pre-prepare their dishes in batches before the peak period to cater the large quantities of customer coming in at the same time. However, there are risk of unsold food if production in batch. Besides, dishes such as noodles if pre-prepared will affect the quality of the food. These will contribute to the decrease in revenue and increase the food waste generated. Prepare upon order is suggested especially for orders near to the closing time. With this just CP options, total food waste generated will be decreased by 15%.

Based on the finding by National Solid Waste Management Department in Malaysia, food waste was the highest waste generation in Malaysia with an approximation of 31% to 45% of total waste generated daily. Commercial and industrial sector contributes 31.4% of the food waste being generated daily. The decomposition of food waste at landfills will contribute to the generation of greenhouse gases and methane gases with 21 times more potent than carbon dioxide. Accordance to audit finding, food waste contributes to the largest portion of carbon footprint emission during the hawker operation. Therefore, a total of 4 cleaner production option was generated to reduce the generation of food waste.

4.3.5 CP Options for Ingredient Selection and Material Optimization

CP Option 22 (Monitor the inventory of ingredient)

The inventory of raw ingredient must be controlled to avoid the raw ingredients lost due to expiry. During the food preparation process, system such as first in first out should be complied to prevent wastage of raw ingredients.

CP Option 23 (Elimination of hazardous waste)

Cleaning products are necessary to maintain the healthy and clean condition of the hawker centre. However, conventional cleaning products are often nongreen and possess risk to health and environment. The use of hazardous chemicals such as concentrated dish washing liquid should be eliminated by replacing a greener cleansing agent. For example, cleaning products can be replaced with nontoxic and chlorine free or usage of cleaning products with label of full disclosure on all ingredients. Besides, hawker can also make use of their cooking ingredients such as vinegar as a natural alternatives of cleaning product.

4.3.6 CP Options for Waste Management System at Hawker

CP Option 24 (Bulk Purchases with Others Hawker Vendor)

Bulk purchases are recommended for individual hawker due to the ingredient might spoilt before usage, however, if the bulk purchases are shared within the other hawker vendor who uses the same ingredient will be beneficial. Bulk purchase uses less packing compared to individual packaging material therefore less solid waste was generated. This CP options reduce 15% of solid materials being generated at hawker centre which equivalent to 800.31 kgCO_2.

CP Option 25 (Waste Segregation)

Waste segregation program is relatively important at the hawker centre. Segregation of waste allowed identification of potential reuse, recycle or recovering value of the waste. Consequently, waste can be reduced when the waste segregation was managed effectively. The carbon emission can be reduced up to 10% which equivalent to 533.54 kg CO_2

CP Option 26 (Food Waste Composting)

Instead of throwing the all the waste directly to the bin, food waste should segregate and send for composting which will then transformed into bio-organic compost that can be used in gardening. However, further studies are required to perform for deeper

CP Option 27 (No Plastic Usage)

According to the audit finding, plastic accounts for 65% of solid waste at the hawker centre. By replacing disposable items with reusable plastic plates, glass, or ceramic for dine-ins service. Besides, plastic will be only given for takeaways order with a charge. However, customer that bring their own reusable container can be void with the charge.

CP Option 28 (Reuse and Recycle of packaging material)

Almost all the food or ingredients we ordered comes together with packaging. Cardboard and plastic container are commonly found from the packaging can be reuse or recycle instead of throwing to the bin. According to the audit finding, the current waste collection

CP Option 29 (Donating the leftovers)

According the SWCorp Malaysia, there will be an approximate of 24% of food waste were still edible going into landfill. However, the issues malnutrition and hunger remain a global issue. From the audit findings, there will be leftover food at the end of the operation due to overpreparation and the overproduction was thrown into the bin at the end of the day. By donating the leftover food to local foodbank or joining "The Lost Food Project" can reduces the food waste being generated.

Waste generation in hawker centre is a concern to the environment as the liquid and solid generated are high in pollutant level. According to Singh et al. (2014), there are 18,000 tons of carbon being emitted to the environment by food-related traffic yearly. Therefore, a total a total of 6 cleaner production option to the carbon emission at hawker operation.

4.4 Safety Issues at Hawker Centre

CP Option 30 (Improved on Safety of the Hawker Premise)

To allowed hawker vendor and customer to work and dine at a safety environment, the safety and health of the hawker centre must be concern. During the audit walkthrough, some of the safety concerns had been identified. Based on the audit finding, actions are required to mitigate the concerns. Implementation of CP option on safety and health of hawker centre is to ensure smooth operation for hawker vendor and comfort dining area for customer.

Table 4.15 List of safety issues and action taken to mitigate

No	Safety Issue	Action
1	Slippery floor due to the oil and grease from the cooking process	- Install oil baffle at the gas stove - Grinding treatment to the floor surface.
2	Hot surface for area near the stove	- Placing Caution Hot Surface Hazard Sign - Avoid overcrowding in the kitchen area;
3	No proper place to keep sharp object such as knifes.	- Prepare a proper storage holder and it is not accessible by customer.
4	Dull blade	- Keep your knives sharpened so you don't need to strain while chopping, slicing, or dicing.
5	Leaking faucet at sink of beverage counter	- Block access to wet areas and use of cautionary signage. - Call for servicing of the leaking
6	Dirty dishes and bowls are collected and then dumped in plastic containers filled with soapy water and flies for hours before they are washed and reused	- Have a dishwashing schedule, cleaning it batch by batch to avoid accumulations. - Application of dishwasher for dishwashing
7	Gas leaking from LPG tank	- Install LPG gas leak detector alarm
8	Uneven and deteriorated floor surfaces	- Block access to wet areas and use of cautionary signage.

With the presence of sharp equipment, tight space and opens flames, there are a lot of possibilities that accident will occurs at the hawker centre. To ensure the safety of hawker vendor as well as customer, it is relative important for the hawker centre owner and hawker vendor to aware of listed problem and overcome the issues as soon as possible. With the action suggested, hawker centre can reduce the risk of common injuries and fire.

4.5 Recommendation for CP Implementation

Accordance to the audit findings and carbon footprint analysis, it has shown that the electricity was one of the major components that contribute to the carbon emission at hawker centre. Based on the generated CP option discussed earlier, CP options that doesn't requires investment cost will be implement immediately. Whereas for other CP option will be implemented when sufficient fund in available. The carbon emission will be reduced up to 1,125.10 kgCO_2 after CP option implementation. The CP options recommended for reduction of electricity consumption are as listed.

Table 4.16 Suggested CP option on electricity and respective carbon reduction

No	CP Options	Reduction of electricity consumption per month (kWh/month)	Reduction of carbon emission (kg CO_2/ month)	Payback Period
1	Rearrange of hawker vendor position	608.01	407.37	Immediate
2	Switched off unnecessary appliances	145.60	97.60	Immediate
3	Switched off light	140.40	94.00	Immediate
4	Usage of LED light	436.02	292.13	9 months
5	Invest in Energy Saving Appliances	349.20	234.00	2 years 9 month

Aside from the electricity usage, water is the main resources that requires for smooth operation of hawker centre. Water is involved in most of the process at hawker centre, from provides hydration to hawker vendor, food preparation, cooking to cleaning of the hawker centre. After the CP implementation, a total of 470.59 kg CO_2 being reduced. As the reduction of the water consumption, wastewater production will also be reduced. This is because the suggested CP options except CP option 7, This is because CP option targeting the uses the rain which only decrease the generation, whereas other options suggested were targeting the reduction of flow through the tap.

Table 4.17 Suggested CP option on water and respective carbon reduction

No	CP Options	Reduction of water consumption per month (m^3/month)	Reduction of carbon emission (kg CO_2/ month)	Payback Period
6	Installation of Tap Aerator	76.44	61.15	5 months
7	Reuse of water	55.20	44.16	Immediate
8	Avoid washing under tap	115.30	92.24	Immediate
9	Dishwasher for dish cleaning	220.80	176.64	1 year and 8 months
10	Fixture of leaking pipe	120.50	96.40	Immediate

Consumption of LPG fuel in the hawker centre contribute quite a huge portion on carbon emission. CP option must be generated to reduce the usage of fuel. Implementation of suggested CP will reduce 14565.8kg CO_2 of carbon emission.

Table 4.18 Suggested CP option on fuel – LPG and respective carbon reduction

No	CP Options	Reduction of fuel consumption per month (liter/month)	Reduction of carbon emission (kg CO_2/ month)	Payback Period
11	Using Pressure Cooker	5600.10	8568.20	Immediate
12	Right amount of water	2800.00	4284.00	Immediate
13	Cooking on low flame	1120.02	1713.60	Immediate

Food waste in this case accounts for the highest release of carbon dioxide emission compares to others factor. The suggested CP option will be implemented immediately to reduce the food waste produce. 13504.8 kg of carbon emission is avoided after CP option being implement.

Table 4.19 Suggested CP option on food waste generation and respective carbon reduction

No	CP Options	Reduction of food waste generation per month (kg/month)	Reduction of carbon emission (kg CO_2/ month)	Payback Period
14	Selling dishes using same raw material	1688.10	3376.20	Immediate
15	Knowing the customer flow pattern	2532.15	5064.30	Immediate
16	Avoid batches production	2532.15	5064.30	Immediate

Suggested CP option does not require any investment cost; thus, implementation of recommended will performed immediately. The suggested CP option will reduce 1333.71kg CO_2 emission

Table 4.20 Suggested CP option on solid waste generation and respective carbon reduction

No	CP Options	Reduction of food waste generation per month (liter/month)	Reduction of carbon emission (kg CO_2/ month)	Payback Period
17	Waste Segregation	144.20	533.40	Immediate
18	Bulk Purchasing	216.30	800.31	Immediate

Table 4.21 carbon footprint emission before and after CP implementation

Item	Before CP implementation		After CP implementation	
	CO_2 emission (kgCO_2 / month)	kg CO_2 per customer	CO_2 emission (kgCO_2 / month)	kg CO_2 per customer
Electricity	10,944.35	0.13	9,819.25	0.12
Water	1,153.60	0.01	683.01	0.01
LPG	28,560.51	0.33	13,994.71	0.16
Food waste	53,762.00	0.63	40,257.20	0.47
Solid waste	5,335.40	0.06	4,001.69	0.05
Wastewater	1,634.41	0.02	1,033.87	0.01
Total	**101,390.27**	**1.18**	**69,789.73**	**0.82**

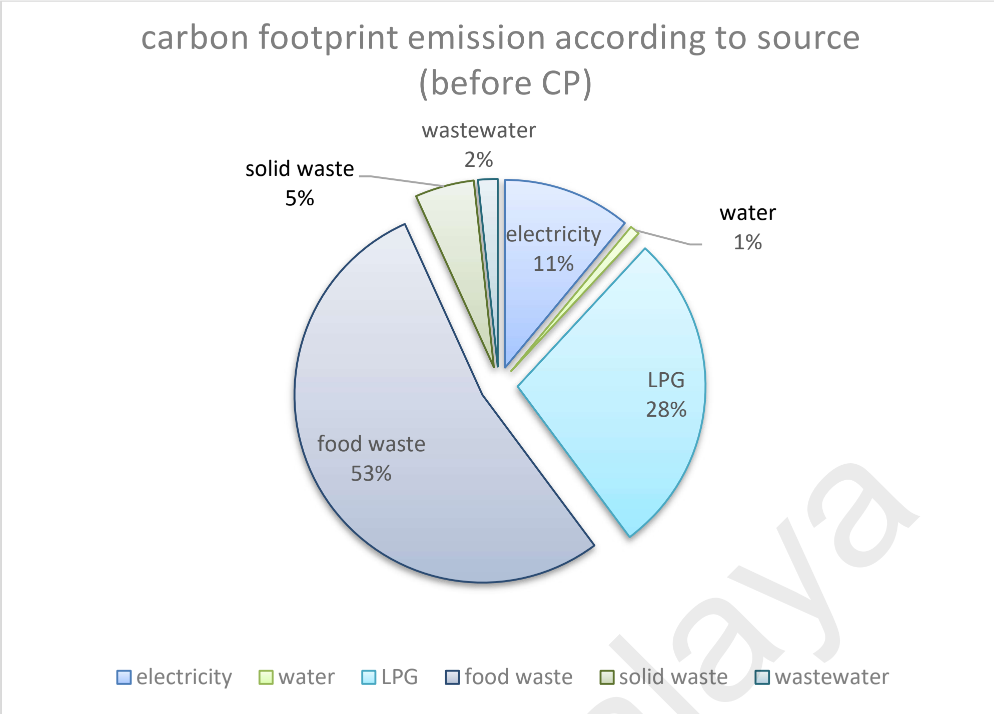

Figure 4.2 Carbon emission ($kgCO_2$) accordance to source before CP

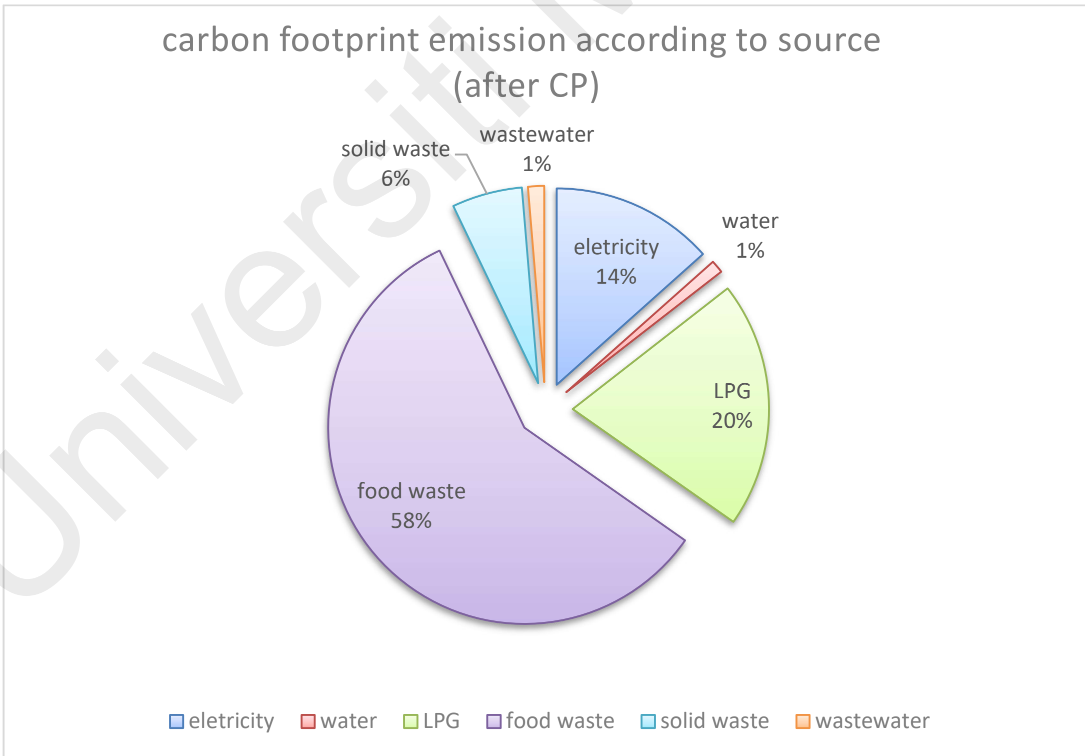

Figure 4.3 Carbon emission ($kgCO_2$) accordance to source after CP

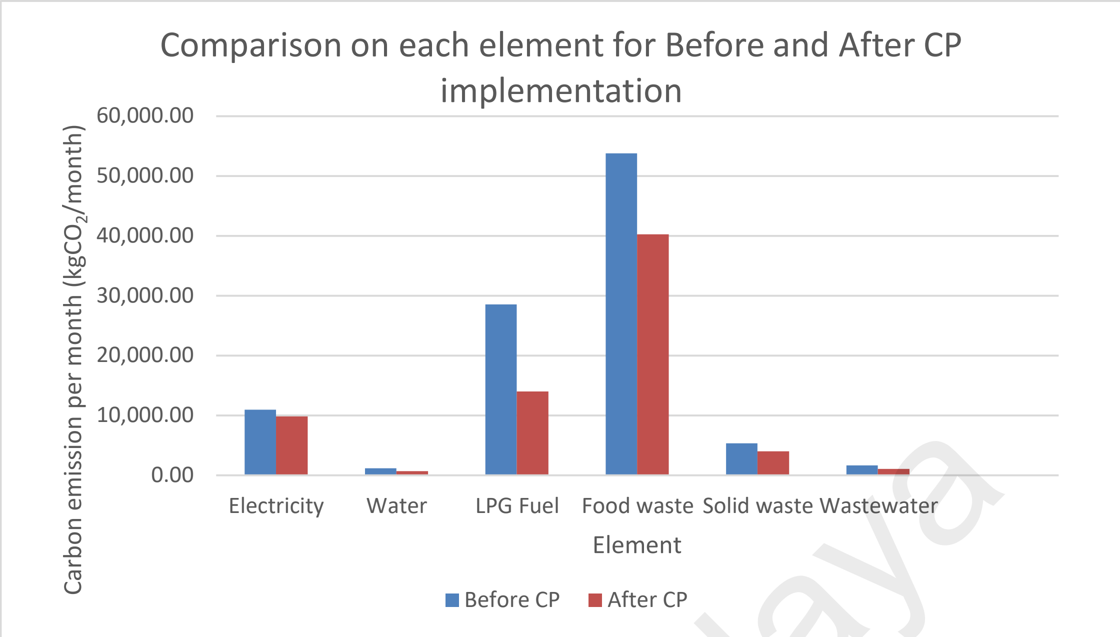

Figure 4.4 Comparison on each element for Before CP and After CP implementation.

According to Figure 4.2, food waste accounts for the largest carbon emission on the hawker activities followed by LPG fuel which accounts for 28% of the total emisssion. With the implementation of suggested CP options, a sharp decrease can be observed at the LPG fuel emission which accounts of 51% on fuel reduction. This is because the suggested CP option number 11, cooking with the pressure cooker can fasten the cooking procedure by trapping the steam in a sealed chamber. As the steam in the sealed chamber builds, pressure in the chamber increases and lead to boliing point of water past 100^{o}C. This shortnes the cooking times and lack of evaporation from the sealed chamber allows the food to extract flavour more effiecnently. For the case of food waste, a total of 25% of carbon reduction can be achieved soley depends on understanding the needs and patterns of customers.

With the implementation of suggested CP options, the total reduction of carbon footprint emission can be decreased up to 31.17% which is equivalent to 0.36 $kgCO_2$ of carbon reduction per customer. Even though the suggested CP option had been implemented, food wastes are still the major source of carbon emission at the hawker centre. There was total of 18 cleaner production option being suggested with the total investment cost of RM15,513.20 and the annual savings of RM 12,900.20. The total payback period will be calculated as:

Investment Cost = RM 15,513.20

Annual Saving = RM 12,900.20

$$Payback\ Period = \frac{Investment\ cost}{Annual\ Saving} = \frac{RM15{,}513.20}{RM12{,}900.20}$$

$$= 1\ year\ and\ 3\ months$$

CHAPTER 5: CONCLUSION AND RECOMMENDATION

There were total of 30 cleaner production option being identified which includes the efficiency usage of resources such as fuel, water, and energy. Besides, cleaner production on reducing the generation food waste and solid waste was also identified. Out of the 30 CP option generates 18 cleaner production option being suggested with the total investment cost of RM 15,513.20 and the annual savings of RM 12,900.20. The total payback of the cleaner production option generated is within 1 year and 3 months.

It was estimated to reduce 31.17% of carbon emissions which is from 1.18 kg to 0.82 per customer. Even with the implementation of cleaner production, there were 69,789.73 kgCO_2 being produce monthly which equivalent to 837,476.76 kg of carbon dioxide being released yearly. According to Misni et al. (2015), a at least 10 year old Pulai (Alstonia angustiloba) tree with height of 11 to 22m and diameter of 11 to 26 Dbh can absorb an average of 3,433 kg of carbon per year. Hence, a total of 244 Pulai tree need to be planted to offset the yearly emission of the hawker centre.

Based on the analysis, CP strategies can decrease the carbon footprint emission of hawker centre and it showed that the cleaner production is feasible environmentally and environmentally. Therefore., CP suggested should be adapted as soon as possible to produce a greener and safer environment

As this research study was conducted during the Covid-19 pandemic, dine in information collection was insufficient which contribute to lesser utility consumption and waste generated. Hence, is important to conduct CP audit during the normal operation of hawker center to identify the carbon generation. In this study, carbon dioxide emission only considered the raw material carbon emission. Thus, it is suggested to consider the cooking time and cooking method into the calculation of carbon footprint produced by each food. Some of the suggested CP option requires further studies, such as switching of gas stove cooking to electrical cooking requires as the usage of electrical cooking can reduce the LPG fuel usage, however, it will increase the carbon emission on the electricity. Whereas for future research work, this study will be useful and serves as a primary model in establishing CP option. in food service sector.

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