TRACTION
ENERGY ASIA

Research Report

Used Cooking Oil Availability and Collection Models in Indonesia for Used Cooking Oil as a Biofuel Feedstock

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Ahmad Juang Setiawan
Refina Muthia Sundari
Anisa Dwi Ariyani
Mickhael Rajagukguk
Rinanda Dwirintha Putri

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Executive Summary

Indonesia holds significant potential to utilize Used Cooking Oil (UCO) as a sustainable and environmentally friendly feedstock for biofuel production. Optimizing UCO collection can reduce dependence on palm oil expansion, which contributes to deforestation and environmental degradation. By repurposing UCO for biofuel, Indonesia can advance its renewable energy goals while mitigating the environmental impact of land conversion for new palm oil plantations.

This report analyzes UCO availability in the industrial sector, particularly in the Hotel, Restaurant, and Café (HoReCa) sector and food manufacturing industry. These sectors generate approximately 933,168 kL of UCO annually, with 218,871.7 kL sourced from HoReCa and 714,296.6 kL from food manufacturing.

Distribution of potential UCO volume per-month by HoReCa Industry by province

Distribution of potential UCO volume per-month by Manufacture of Food Products per province

The distribution of UCO potential in the HoReCa industry is concentrated in provinces with major cities and high tourism activity, such as North Sumatra and South Sulawesi, which record the highest tourist visits in their respective regions. This pattern indicates a positive correlation between UCO potential and tourism levels. Meanwhile, UCO production in the food manufacturing industry is primarily concentrated in Java, with Lampung being the highest producer outside the island. Key factors influencing the location of these industries include market presence, infrastructure, land availability, and workforce accessibility, which contribute to the limited number of food processing industries in DKI Jakarta and DI Yogyakarta.

However, several challenges hinder UCO collection and management, including price fluctuations, inconsistent handling practices, and reliance on local markets. Additionally, UCO loss rates vary across industries:

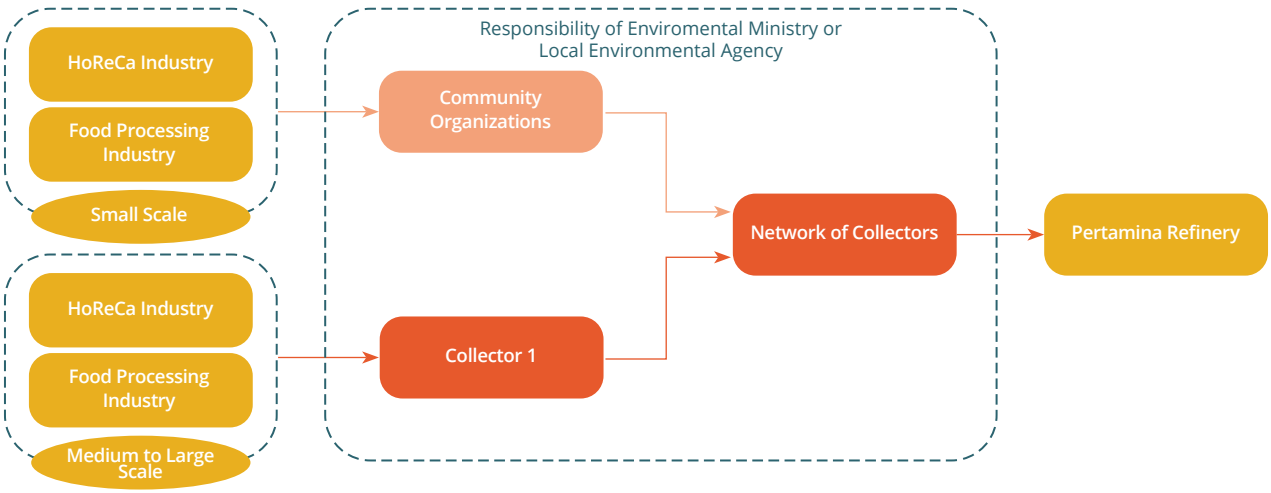
- HoReCa loses 52% of used oil, leaving 480 ml of UCO per liter of oil used.
- Food manufacturing loses 75%, leaving only 250 ml of UCO per liter used.

Moreover, UCO pricing disparities exist, with HoReCa UCO priced at IDR 5,000 – IDR 5,900 per liter, whereas food manufacturing UCO ranges from IDR 3,000 – IDR 3,900 per liter.

To enhance UCO utilization and support Indonesia's transition to renewable energy, this report proposes an integrated UCO collection model involving three key stakeholders:

1. Community organizations
2. Private collectors
3. Local Environmental Agencies

Ideal multi-stakeholder UCO collection model



Implementing a structured and sustainable UCO collection system will enhance efficiency, sustainability, and distribution, aligning with Indonesia's renewable energy targets. By maximizing UCO as a low-carbon biofuel feedstock, Indonesia can reduce deforestation pressures and accelerate its energy transition. This report provides a foundation for policymakers, industry players, and stakeholders to develop effective UCO governance frameworks and foster cross-sector collaboration for a more sustainable energy future.

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1. INTRODUCTION

1.1. Background

As a result of the Renewable Energy Directive II (RED II) policy, the target for using UCO as a raw material for biofuel in the European Union has significantly increased. This encourages EU countries to meet the increased demand for UCO from countries such as Indonesia. Furthermore, Indonesia's membership in the International Civil Aviation Organization (ICAO) obligates the country to adhere to the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which targets a reduction of 2.6 gigatons of CO_2 emissions by 2040. Established by ICAO, this initiative aims to cap aviation emissions at 2020 levels while supporting global climate objectives through advancements in fuel efficiency, sustainable aviation fuels, and low-carbon technologies. ICAO has identified the implementation of Sustainable Aviation Fuel (SAF) as a key strategy for achieving sustainable aviation, with UCO serving as one of its primary feedstocks.

Indonesia produces significant quantities of UCO, which could be used to supply domestic biofuel needs sustainably by reducing the threat of deforestation from growing more unsustainable palm oil. The results of a study by Kristiana et al., (2022) estimated that the potential for UCO collection in Indonesia reached 715 kilotons or equivalent to 794,444 kL per year, exceeding other major UCO exporting countries such as Japan, Malaysia, and South Korea.

Although Indonesia generates a substantial volume of UCO, greater efforts are still needed in the collection. This is due to several factors: (1) the costs involved in hiring collectors, (2) the need to incentivize consumers to collect and sell UCO at affordable prices for industrial use, and (3) the high costs associated with cash-before-delivery transactions; except for UCO sourced directly from accommodation, food and beverage service activities and the manufacture of food products.

Based on the results of Traction Energy Asia's 2022 study, the estimated potential availability of UCO from the Household and Micro Small Enterprises (MSMEs) sector is 1.2 million kiloliters (kL) per year. In the household sector, estimates of the potential availability of UCO are influenced by cooking behavior and the number of family members. Meanwhile, in the MSME sector, the potential availability of UCO is strongly influenced by business scale (Traction Energy Asia, 2022). The results of the study reflect that there is considerable potential for UCO availability in the business sector or industry. Industry groups can be categorized into three classifications based on the number of workers and the revenue earned: (1) small industry, (2) medium industry, and (3) large industry.

The industrial sector with the potential to be a source of UCO production includes the food sector, which consists of: (1) the food and beverage Industry sub-sector within the Non-Oil Processing Industry, and (2) the Accommodation, food and beverage service activities sector. The food and beverage sub-sector consistently makes the largest contribution to the added value in the Processing Industry sector. In 2022, the sub-sector contributed 34.47% to the added value of the Processing Industry (BPS, 2023).

Meanwhile, the accommodation, food and beverage service activities sector is the second-fastest growing economic sector, following the Transportation and Warehousing sector, in the same year (Ministry of National Development Planning/Bappenas, 2023). The sector grew by 11.97% in 2022. The growth rate was driven by the accommodation sub-sector, which increased from 5.79% in the previous year to 31%. In addition, the growth of the food and beverage Sub-sector also increased from 3.52% to 8.23% in 2022.

Industries that use cooking oil in their production processes, such as instant noodle, snack, and cracker manufacturers, require substantial amounts of cooking oil and have significant potential to generate used cooking oil or UCO. Suharyanto et al (2021) explained that a cracker factory with a production capacity of 300-500 kilograms per day requires 89.92 kg of cooking oil. Meanwhile, the potential volume of used cooking oil generated by the manufacture of food products is estimated at 128 kilotons (kt) per year (Kristiana et al., 2022a). However, there is no detailed information available regarding the amount of used cooking oil generated by the manufacture of food products industry based on its depreciation during the production process.

Meanwhile, in the accommodation, food and beverage service activities sector (HoReCa), the estimated volume of used cooking oil collected from restaurants can reach 332 kilotons per year (Kristiana et al., 2022). However, there is no detailed information about the average cooking oil usage in restaurants and hotels, so the percentage of depreciation from cooking oil to waste generation cannot be calculated.

Therefore, a study on the potential availability of UCO in the industrial sector is necessary to address the data gaps regarding used cooking oil generation and cooking oil usage patterns in each industrial sector. In addition, this study is expected to provide other relevant data and information, such as UCO pricing and management, including waste management practices currently being implemented in the industrial sector.

1.2. Aims and Objectives

This study aims to:

a. Identify the potential availability of UCO from waste generated by the industrial sector.
b. Identify cooking oil usage patterns in the manufacture of food products and the accommodation, food and beverage service activities sectors.
c. Identify UCO management strategies and prices per liter from the industrial sector;
d. Recommend distribution flow patterns from the industrial source to the final container.

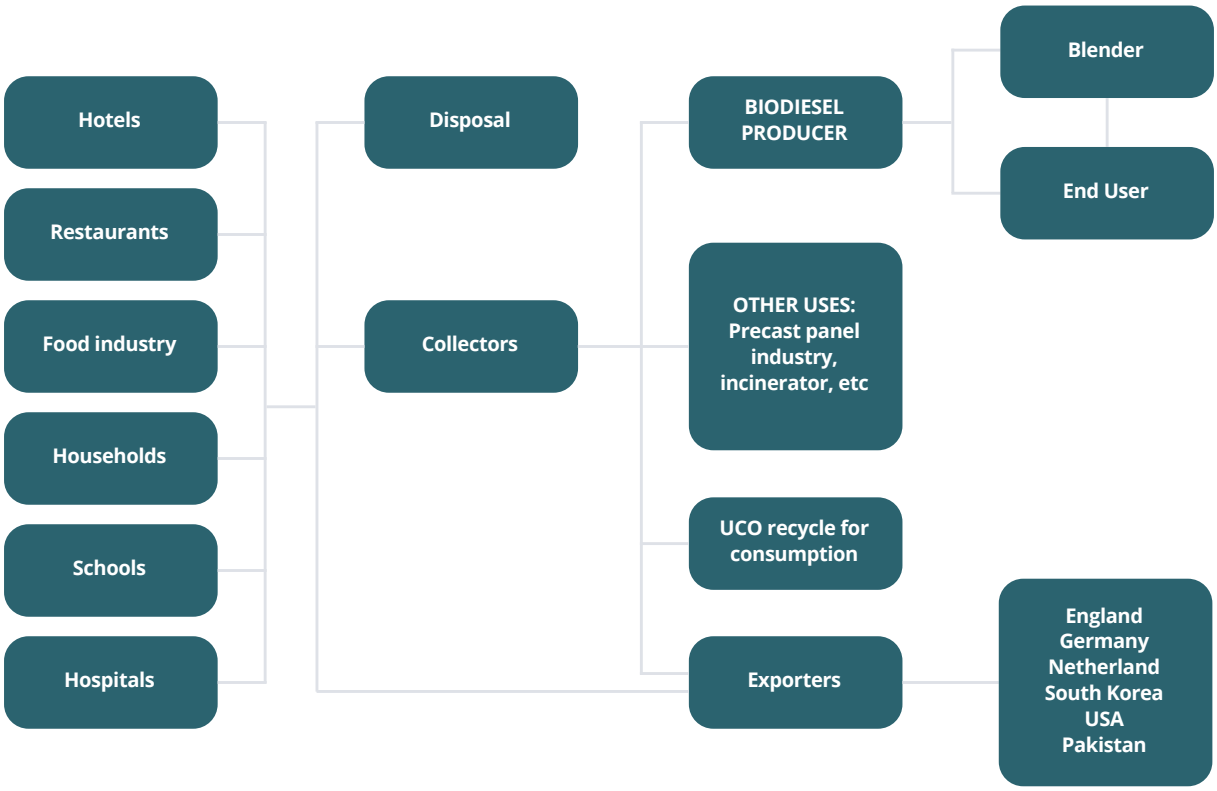
The purpose of this study is to: (1) identify the potential availability of UCO generated by the industrial sector, and (2) formulate the distribution flow, governance, and business management schemes for UCO from the industrial sector.

2. LITERATURE STUDY

2.1. UCO Business in Indonesia

Several studies on the trading practices of used cooking oil as a biofuel feedstock have been conducted. Kharina et al (2018) shows that there are already a number of parties who use UCO as a trading commodity. The parties involved sell used cooking oil to exporters, biofuel producers, and, in some cases, recycle it into reconditioned cooking oil. Used cooking oil is still regarded as disposable waste in centralized waste treatment plants. In fact, the general public still disposes of used cooking oil directly into sewers (Traction Energy Asia, 2022). Figure 1 illustrates the distribution of used cooking oil from various sources to collectors, exporters, and *biofuel* producers.

Figure 1. UCO Producing Sector in Indonesia



Sumber: Kharina et al (2018)

The use of UCO as a trading commodity is regulated under the Regulation of the Minister of Industry of the Republic of Indonesia Number 32 of 2024 concerning the Classification of Palm Oil Derivative Commodities. Traded UCO must meet the specifications as stipulated in the regulation, including:

1. *Totox Value* ≥15.0 mmEqO2
2. Peroxide Number ≥5.0 mmEqO2
3. *Total Polar Matter* ≥ 10.0%-mass

On the other hand, there are no regulations governing the purchase price range of used cooking oil to stabilize used cooking oil methyl ester (UCOME) prices or ensuring its availability for use as a biofuel. Currently, business actors purchase used cooking oil from various sources at varying prices, as shown in Table 1. The purchase price of used cooking oil can influence the selling price of UCOME as a biofuel feedstock, as it serves as the primary raw material in the production process.

Table 1. UCO purchase price in Indonesia

UCO Price (IDR)	References
0 - 500 per liter	(Yandri, 2012); (Prasetyo, 2018)
1.000 - 2.500 per liter	(Asthasari, 2008)
3.000 per liter	(Erviana et al., 2018)
3.000 - 9.000 per kg	(Santoso et al., 2022); Kumparan (2021)
4.000 - 5.000 per liter	(Budiyoko et al., 2022)
5.000 per liter	Bali Portal News (2022)
6.000 - 8.000 per kg	Kompas (2022)
20.000 per liter	Pemkab Hulu Sungai Utara (2020)

Source: Traction Energy Asia (2023).

Several regions have issued regional regulations regulating the management and utilization of UCO. Examples include the Regulation of the Governor (Pergub) of DKI Jakarta No. 167/2016 concerning cooking oil waste management, and Bogor City Regional Regulation (Perda) No.1/2014 on environmental protection and management. Both regulations share a common focus on the management of used cooking oil by business entities or industries, as they have the greatest potential to produce it in large quantities.

Table 2. Summary of UCO Management of Regulation in Jakarta and Bogorr

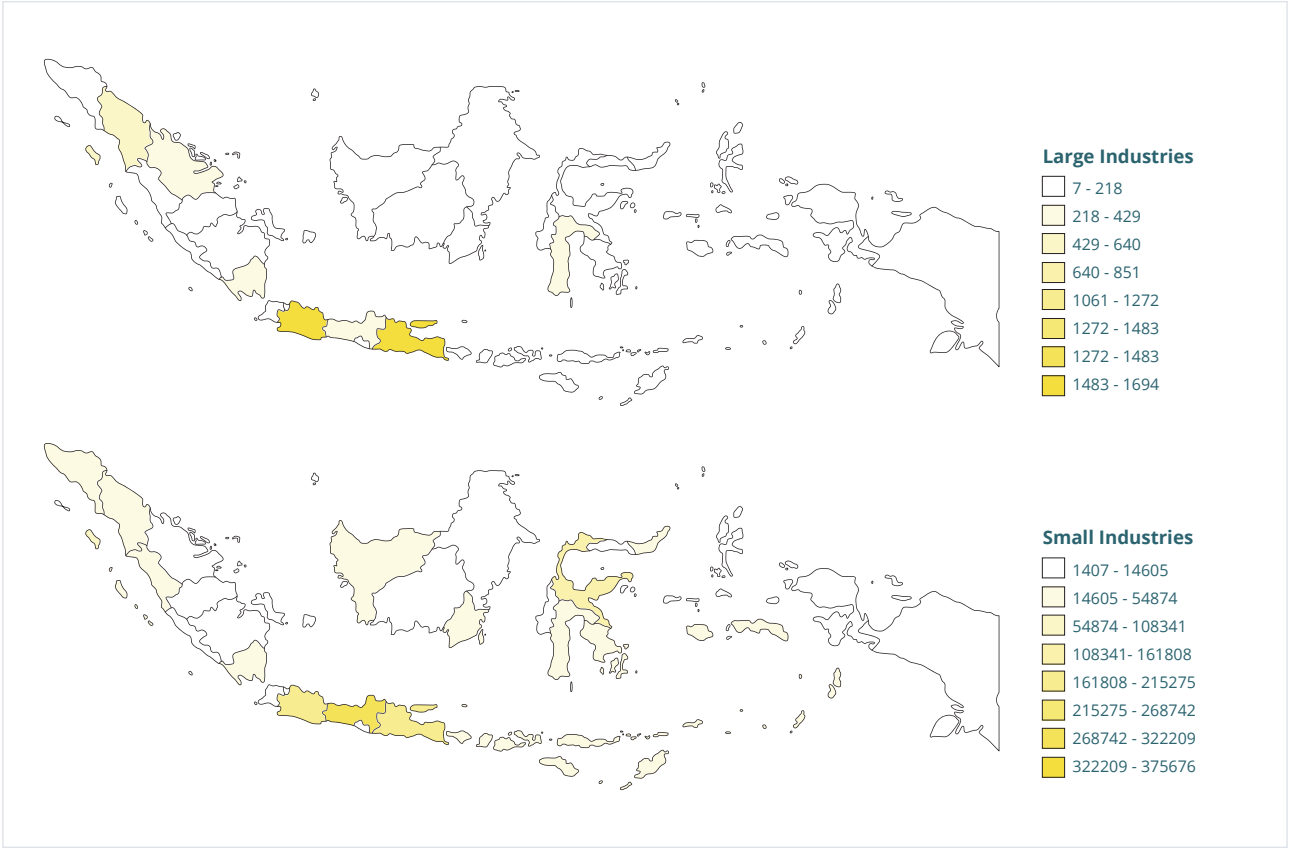
	Jakarta Governor Regulation No. 167/2016	Bogor City Regulation No. 1/2014
Target Groups	• UCO Producer (restaurant, hotel, food industry) • used cooking oil Collectors and • Distributors | used cooking oil Users (*biofuel* production)	The general public, schools, and business actors in the culinary sector who produce UCO, both large and small businesses.
Restrictions	• Reusing UCO • Disposing UCO into environmental media	Disposing of used cooking oil directly into environmental media.
	Producers: • Storing used cooking oil before submitting it to the Local Government. • Report to the Local Government Collector. • Having dedicated transportation and storage facilities. Biofuels *producer*: • Fulfilling Indonesian National • Standards (SNI) in the production process.	• Anyone who produces used cooking oil can submit it to the Regional Government. • Every entity whose business activities produce used cooking oil is obligated to submit the used cooking oil from its operations to the Regional Government.
Penalties	• Administrative penalties in the form of temporary suspension of business activities and revocation of business licenses preceded by a warning • Jakarta Governor Regulation No. 167/2016 and written warnings for 7 consecutive days (7 x 24 hours) each.	• Administrative penalties • Criminal penalties in the form of imprisonment for up to 3 (three) months or a fine. • Bogor City Regulation No. 1/2014 at most IDR 50,000,000 paid directly to the Regional Public Cash account.

2.2. Manufacture of Food Products and Sector of Accomodation, Food and Beverage Service Activities in Indonesia

The industrial sector is one of the economic sectors that includes the production of goods and services through the processing of raw materials or semi-finished materials into finished goods. This industrial sector involves various types of companies, ranging from large companies to Small and Medium Enterprises (SMEs). According to the Central Bureau of Statistics (BPS), the industrial sector is categorized into four classes based on the number of workers: household industries with 1–4 workers, small industries with 5–19 workers, medium industries with 20–99 workers, and large industries with over 100 workers.

Based on data from BPS (2023), Java has the highest concentration of manufacture of food products across all categories, including household, small-scale, medium, and large-scale industries. This is attributed to Java's substantial market potential, with a population of approximately 145 million—nearly 60% of Indonesia's total population—combined with more advanced infrastructure development compared to other islands. This aligns with the research by Lopez & Henderson (1989), which states that the location of manufacture of food products is determined by market proximity and the availability of infrastructure.

Figure 2. Distribution of Large-scale (top) and Small-scale (bottom) Manufacture of Food Products



Source: BPS (2018)

Additionally, market potential also influences the number of providers in the accommodation, food, and beverage service activity sector (HoReCa). Market conditions in the HoReCa sub-sector are heavily influenced by the state of tourism in a given area. Increased tourism activity leads to a higher demand for hotels, restaurants, and cafes (Amir et al., 2017a). In Indonesia, tourism activities are primarily centered around nature-based attractions, showcasing the country's natural beauty, such as beaches, mountains, waterfalls, and more. In 2022, the most visited tourist destinations in Indonesia were Bali, followed by Labuan Bajo, Lombok, Bromo, and Borobudur Temple (Central Bureau of Statistics, 2023).

2.3. Theory of Producer Behavior in the Processed Food Industry and HoReCa Sector

Producers consider several key variables in their operations, namely inputs, outputs, and profits. Based on the theory of producer behavior, most producers are normatively assumed to be profit-oriented. Profit-oriented producers consider the balance of inputs and outputs to maximize profits (Osborne & Rubinstein, 2020). In this case, inputs are minimized to produce maximum output, thereby increasing the company's profitability.

In the manufacture of food products, the input composition typically consists of raw materials, utilities, and labor costs. Meanwhile, in the HoReCa sector, *input* costs for producing *output* primarily consist of food ingredient costs and labor expenses. The cost of raw materials and food accounts for 14.5% of the total input costs,

while labor costs dominate the HoReCa sector, making up approximately 52% of the inputs. The remaining proportion of inputs in the HoReCa sector is allocated to utilities, marketing, maintenance, and other operational expenses (Dorfman, 2014).

To maximize output and profits in the manufacture of food products, manufacturers typically optimize working speed, extend working hours, and minimize input costs. Meanwhile, in the HoReCa sector, input costs are managed by controlling food portions, minimizing food waste to prevent unnecessary loss, and optimizing labor hours (Dorfman, 2014). This theory is supported by a study conducted by Traction Energy Asia (2022), which found that the higher the revenue generated by producers, the lower the amount of waste produced.

2.4. Externality Theory

Externalities are a type of market failure that occurs when the activities of economic actors affect others, but these impacts are not accounted for in market transactions. One example of a negative externality from the production process is the waste generated during frying, particularly used cooking oil. This type of waste can have harmful effects on the environment and public health, highlighting its significance as a negative externality.

For example, if used cooking oil contaminates water bodies, it can deplete oxygen levels, making it difficult for aquatic organisms to breathe and ultimately threatening their survival. In addition, used cooking oil can clog water treatment plants, contaminate shorelines, and become flammable near ignition sources due to its lower flash point (EPA). Used cooking oil is also toxic. The degraded components in waste cooking oil (brown oil) can pose significant health risks, including enzyme dysfunction in the intestinal mucosa, diarrhea, and the potential for mutations in body tissues, which may act as precursors to cancer (Food and Drug Supervisory Agency (BPOM), 2023).

2.5. Cooking Oil Use Patterns and Waste Management in the Industrial Sector

In the manufacture of food products, one method of food preparation involving heating is frying. The frying process is an important mechanism for the food industry because it extends the shelf life of food and changes the shape, taste, and aroma of food. There are two types of frying methods commonly used in the manufacture of food products: shallow frying and deep frying. **Shallow frying** relies on heat from a tool or container with a small amount of oil as the medium. Meanwhile, in the **deep frying** process, the entire surface of the food is submerged in hot oil as the main medium (Saguy & Dana, 2003).

The frying method in the food industry is one of the key factors influencing production time, alongside the type of food, oil temperature, and the thickness of the ingredients. The temperature and heating time greatly affect the oil used in the production process. Oil that is heated continuously at high temperatures for a long time will blacken and smell rancid. This indicates that the quality of oil has been degraded and will affect the processed food. In addition, to maximize the results of food processing in terms of color and taste, several key factors are considered in the industry, including (a) the type of cooking oil used; (b) the age and frequency of heating; (c) surface tension between

the oil and the product; (d) frying temperature and time; (e) the size, humidity, and surface characteristics of the food; and (f) post-frying treatment (Saguy & Dana, 2003).

Large-scale industries usually have implemented food production and waste management mechanisms that meet international standards. For food safety, large industries use Good Manufacturing Practices (GMP) standards and adopt various international certifications. The types of certifications adopted by major industries include:

(a) ISO 9001; (b) food safety management system through Hazard Analysis and Critical Control Point (HACCP), ISO 22000, Food Safety System Certification (FSSC) 22000, and AIB international standards; and (c) laboratory competency standards through ISO 17025. As for waste management, there are 2 (two) divisions of management based on the type of waste, namely non-hazardous waste and hazardous waste management. For non-hazardous waste in solid form, the principles of 3R management or Reduce, Reuse, and Recycle can be applied. For hazardous waste, all waste is stored in licensed facilities before being handed over to and reprocessed by third parties.

On a smaller scale, the Food and Drug Supervisory Agency (BPOM) has issued guidelines that regulate how to choose the recommended cooking oil preference and frying method. In the guidelines, the type of cooking oil used is divided into liquid and solid cooking oil. Each type of cooking oil has differences in properties including the state at room temperature, storage requirements, usage methods, and the texture of the fried products produced. One example of this difference is that food fried with solid cooking oil tends to be drier and crispier compared to food fried with liquid cooking oil. Based on this information, the choice of cooking oil type depends on the desired characteristics of the food products being produced.

In addition to the type of cooking oil, the frying method also influences the characteristics of the processed food products. There are four frying methods commonly used in small and medium industries as outlined in the guidelines, namely:

a. **Deep frying**
   This frying method involves submerging food completely in a large volume of oil during the frying process. In this method, the ratio of food to cooking oil is typically 1:6, ensuring the food is fully submerged for even cooking. Commonly processed ingredients using this method include potatoes, chicken, fish, croquettes, donuts, and similar foods.

b. **Shallow frying**
   This frying method involves partially submerging the food ingredients in oil, commonly used for frying items like tempeh, tofu, fritters (bakwan), and potato cakes (*perkedel*).

c. **Saute frying / Stir-frying**
   Food products made using this method are commonly called “stir-fry”. This method uses a minimal amount of oil (sautéing) and is typically used to cook spices, vegetables, and similar ingredients.

d. **Vacuum frying**
   This frying method is performed under vacuum conditions and requires a significant amount of cooking oil. The temperature of the cooking oil in this frying process is relatively

low, ranging from 80C to 90C. This method is used to process various kinds of chips derived from fruits, such as apple chips, jackfruit chips, and others.

In the management of used cooking oil, the guideline also calls for avoiding the use of frying used cooking oil repeatedly. Moreover, when the residual oil from frying is brownish-black and smells rancid. However, in practice, there are still some small industry players who ignore this advice and continue to reuse oil. The survey results from the Traction Energy Asia study (2022) show that there are small industry players who still use cooking oil until there is nothing left in their processed products.

In the accommodation, food and beverage service activities sector, cooking oil usage also follows accommodation, food and beverage service activities sector standards set for each business actor to ensure that the food, drinks, and services provided are safe for customers. The frying process in the accommodation, food and beverage service activities sector is similar to that in the manufacture of food products*, including methods such as deep frying, shallow frying, stir-frying,* and *vacuum frying*. However, there are certain parts or places for food processing, according to its functions. Khairunnisa et al. (2022) explained that in the hotel industry, to facilitate operations while ensuring good food quality, there are four types of kitchens based on their respective functions, namely:

a. ***Conventional Kitchen***
   This type of kitchen is found in almost all types of hotels, both star hotels and small hotels. The activities carried out in these kitchens include the preparation, processing, and serving of food. In this kitchen, activities are using cooking oil to process various kinds of dishes needed.

b. ***Combinated Preparation & Finishing Kitchen***
   This type of kitchen is different from a *conventional kitchen* because food preparation activities and food processing activities are carried out in separate areas. This kitchen is typically found in large hotels that have enough space to separate the two activities.

c. ***Patisserie***
   This type of kitchen focuses on processing snacks such as cakes, bread, sweets, ice cream, and other desserts. The preparation of these foods typically involves the use of butter, with cooking oil used as a substitute or supplement in small quantities.

d. ***Convenience Kitchen***
   This kitchen is used for preparing finished food or providing food service, with no storage of raw materials or cooking utensils.

2.6. Framework and Operationalization of Concepts

Based on the literature study, the researcher developed a conceptual framework comprising two aspects: the scope of production behavior involving the use of cooking oil and the externalities of cooking oil by-products generated during the production process. The scope of production behavior includes the amount of costs and inputs, the costs and quantity of outputs, as well as profits (Osborne & Rubinstein, 2020). In the context of cooking oil usage,

consumption activities encompass the volume and frequency of purchases, usage patterns, and the management of oil as waste or by-products (Amalia & Rahmayani Johan, 2010).

Processing used cooking oil is crucial to mitigate environmental and health impacts that may arise if the oil is improperly discarded or left unmanaged. In addition, used cooking oil *as* a by-product can be repurposed into non-food products such as biofuels, candles, soaps, and more (Hadiguna & Putra, 2015). Therefore, the manufacture of food products, as well as the accommodation, food and beverage service activities sector, often opt to sell the used cooking oil at a certain price.

This study utilizes the aforementioned theoretical propositions to examine production behavior, including *input* costs and quantities, *output* costs and quantities, and *profits*, as well as the externalities of cooking oil by-products, particularly their volume and price. Furthermore, the conceptual framework is translated into the operationalization of the following concepts.

Table 3. Operationalization of the Concept

Concept	Variable	Dimensions	Indicators	Scale
Scope of Production Activities (Osborne & Rubinstein, 2020); Dorfman, 2014)	Use of raw materials	Preferences	Type of cooking oil used	Amount
		Price	Purchase Price	Ordinal
		Quantity	Usage volume	Ordinal
		Frequency	Frequency of usage	Ordinal
		Behavior	Usage method	Amount
	Workforce	Priorities	Labor certification	Amount
		Quantity	Total manpower	Ordinal
		Price	Salary	Ordinal
	Product	Preferences	Types of products	Amount
		Quantity	Number Of Products	Ordinal
	Income	Price	Product selling price	Ordinal
Used cooking oil externality	Used cooking oil Quantity		Amount of used cooking oil	Ordinal
		Behavior	Standards Used for Managing Used Cooking Oil	Amount
		Price	The selling price of used cooking oil	Ordinal

2.7. Hypothesis

This study tests the hypothesis for respondents in the industrial sector in the following areas:

"The volume of Waste Cooking Oil (UCO) generated in the industrial sector is influenced by production processes, business scale, revenue, and used cooking oil management practices"

3. RESEARCH METHODS

3.1. Research Approach

This study uses a quantitative cross-sectional approach (De Vaus, 2002) to compare the behaviors of three groups: large, medium, and small industries. The target respondents are classified based on the number of employees:

a. Large industries (> = 100 employees)
b. Medium industry (20-99 employees)
c. Small industry (<20 employees)

This grouping of target respondents is in accordance with the grouping of industries by Indonesia's Central Bureau of Statistics (BPS). In addition, the number of employees reflects the production level of the business and its cooking oil requirements - more employees = higher production output = larger supply of cooking oil.

3.2. Research Location

The selection of the research location takes into account the distribution of the target industry. Based on literature studies, the manufacture of food products places significant importance on proximity to consumers in large urban areas, and adequate infrastructure. For this reason we selected Jakarta, Bogor, Depok, Tangerang, Bekasi, and Karawang (Jabodetabeka) as the research location for our study. The province of Bali was selected as the research location for the Hotel, Restaurant and Cafe (HoReCa) industry given this sector's dependence on high levels of tourism.

3.3. Data Collection Techniques

Data collection was conducted through face-to-face interviews with industry respondents who use cooking oil. During the interview process, questionnaires were used to ensure that discussions were more focused and that the required information was obtained.

Scope of the Manufacture of Food Product Respondents Survey:

- Company identity: (1) Name, (2) Business status, (3) Address, (4) Initial year of operation, (5) Revenue, (6) Operational schedule, (7) Production capacity.
- Human resources: (1) Number of workers, (2) Workers Skill Certificate, (3) Worker remuneration.
- Use of cooking oil: (1) Type of cooking oil, (2) Price of cooking oil, (3) Volume of use, (4) Cooking process carried out.
- Product *output*: (1) Product type, (2) Production quantity, (3) Product price, (4) Byproduct.

- Used cooking oil processing: (1) Volume of used cooking oil produced (2) Standard management of used cooking oil (3) Sales of used cooking oil

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- Product output: (1) Product type, (2) Production quantity.
- Used cooking oil Processing: (1) Volume of used cooking oil produced (2) Standard management of used cooking oil (3) Sales of used cooking oil

Focus Group Discussion (FGD) techniques are also implemented for small-scale industries. This FGD was conducted by inviting small-scale industry participants to a designated location, where a questionnaire was distributed to each of them after an explanation of the study's objectives and goals. Conducting the FGD is expected to make the data collection process more effective and efficient, and to maintain the quality of data obtained from each industry participant.

3.4. Sample framework and sampling technique

The sample framework for this study includes the manufacture of food products in Jakarta, Bogor, Depok, Tangerang, Bekasi, Karawang (Jabodetabeka), and Bali Province. Respondents' criteria are as follows:

Large Industries

- Using cooking oil in the production process
- Located in Jabodetabeka or Bali Province
- Employing 100 or more workers
- Revenue of more than IDR 50,000,000,000 (fifty billion Indonesian Rupiah)

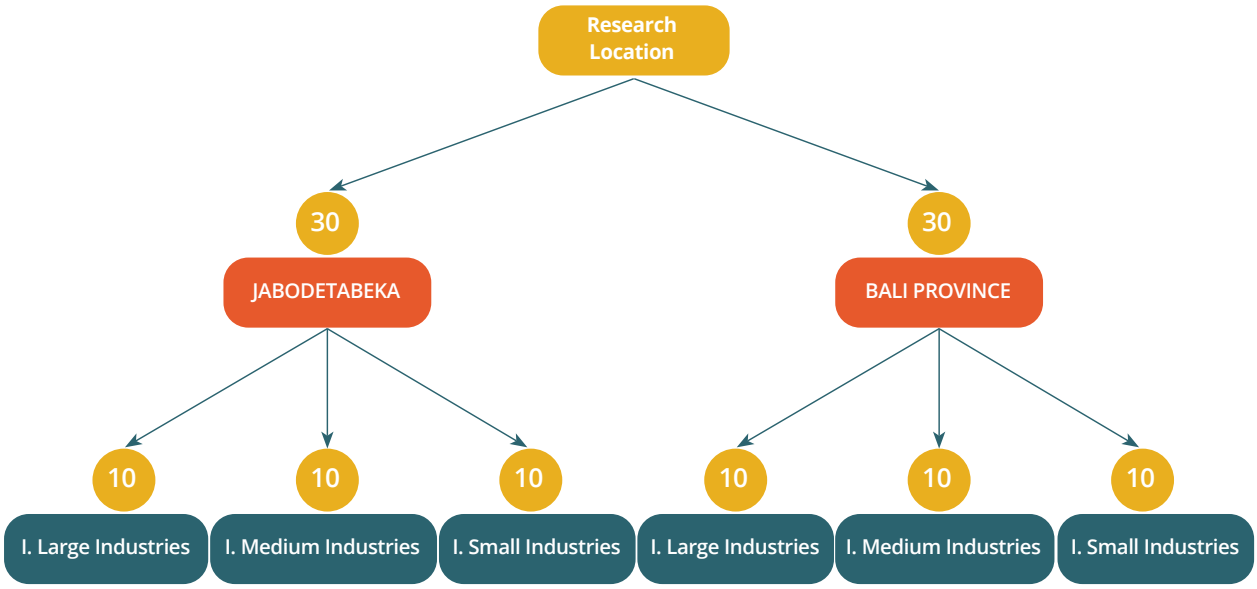
Medium Industry

- Using cooking oil in the production process
- Located in Jabodetabeka or Bali Province
- Employing 20 - 99 workers
- Revenue of IDR 2,500,000,000 (two billion five hundred million Indonesian Rupiah) up to IDR 50,000,000,000 (fifty billion Indonesian Rupiah)

Small Industry

- Using cooking oil in the production process
- Located in Jabodetabeka or Bali Province
- The number of employees is fewer than 20
- Revenue of IDR 300,000,000 (three hundred million Indonesian Rupiah) to IDR 2,500,000,000 (two billion five hundred million Indonesian Rupiah).

Figure 3. The illustration of respondent composition



Sumber: Traction Energy Asia (2023).

The sample framework taken was a total of 60 respondents with the following details:

a. 30 respondents came from the Jabodetabeka region, with 10 respondents at each industrial scale.
b. 30 respondents came from the Bali Province region, with 10 respondents on each industrial scale.

3.5. Data processing and analysis

The data processing of the survey results was conducted using Microsoft Excel and Eviews. The analysis of survey data was carried out in two stages, namely:

a. Descriptive Analysis Results
   Descriptive statistical analysis methods are employed to provide an overview of the data characteristics, describe patterns, and summarize relevant statistics. This method is useful for presenting and interpreting data in detail, whether in the form of tables, graphs, or statistical measures such as averages, modes, ranges of values, and so on. Descriptive statistical analysis is an important foundation for understanding and providing the right interpretation of the research data collected.

b. Inferential statistical analysis

This analysis was used to generalize and draw conclusions about the population based on the samples taken. The method used is multiple linear regression to test two research hypotheses. Multiple linear regression analysis is an instrument to analyze the relationship between the dependent variable (Y) and several independent variables (X) (De Vaus, 2002). In this regression equation, the amount of used cooking oil is the dependent variable (Y), while the independent variables include income (X1), production patterns (X2), and the number of workers (X3).

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e$$

Notes:

Y = Amount of used cooking oil
a = Constant
b_1, b_2, b_3 = Regression Coefficient
e = error/ standard error

X_1 = Production pattern
X_2 = Total workforce
X_3 = Income

4. RESULTS AND DISCUSSION

4.1. Number and Characteristics of Respondents

The data collection process for respondents in the accommodation, food and beverage service activities sector, as well as the food processing industry, was conducted between October and December 2023. A total of 33 respondents from the accommodation, food and beverage service activities sector participated in the interviews, while 30 respondents were involved from the manufacture of food products. It is important to note that due to limited access to large-scale manufacture of food products, the number of respondents from medium-scale industries was increased to ensure strong representation of the industry's conditions. This is also in line with the higher percentage of medium-scale industries compared to small-scale and large-scale industries (BPS, 2023).

Table 4. Number of respondents at each industrial scale

Industry Type	Total		
	Small	Medium	Large
Accommodation, Food and Beverage Service Activities Sector	12	18	2
Manufacture of food products	10	18	2

The characteristics of respondents between the accommodation, food and beverage service activities sector providers and the food processing industry are relatively similar, particularly in terms of understanding production activities, such as human resources in the *kitchen* and operations. However, differences appear when viewed from the industrial scale; namely, the smaller the industrial scale, the better the respondents' knowledge related to production activities. This indicates that on a smaller industrial scale, respondents have direct involvement or in-depth understanding of every aspect of production activities. In terms of the cooking oil usage system and used cooking oil management, the larger the industrial scale, the better the system for cooking oil usage and used cooking oil management will be. This is because large industries have relatively better operational systems and standards than small industries.

4.2. Accommodation, Food and Beverage Service Activities Sector

The accommodation, food and beverage service activities sector has considerable potential for UCO availability because one of its production activities is the preparation of food produced using cooking oil. Despite the income primary focus of this industry is on services provided to visitors rather than cooking activities, the relationship between the scope of production activities and the potential availability of UCO can be observed through several supporting variables. Therefore, production activities, particularly in accommodation providers or hotels, can be focused on areas that use cooking oil, such as food service in restaurants, *ballrooms, bars,* or in-room dining.

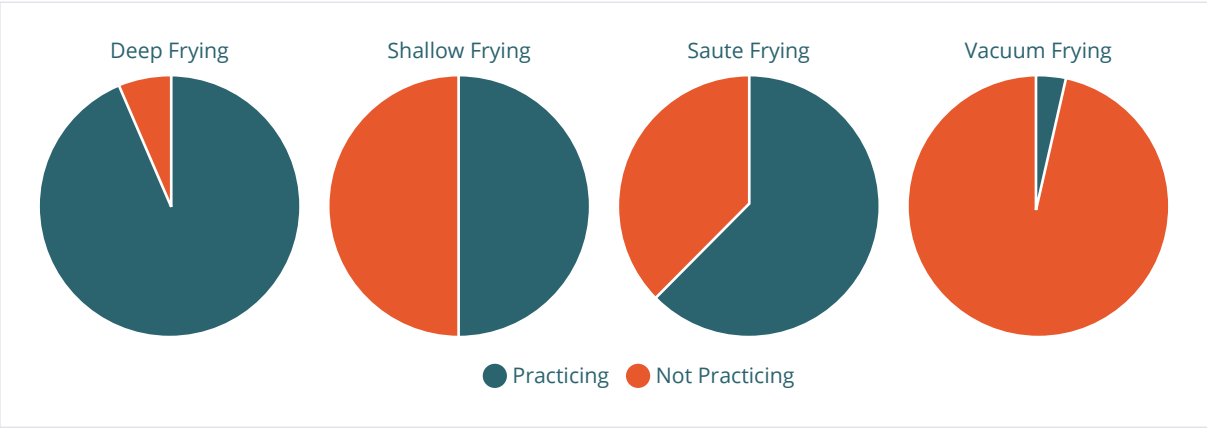
4.2.1. Scope of Production Activities

When conducting production activities, accommodation, food and beverage service activities sector providers must ensure that the quality of the products meets the expectations of guests or customers. This will later affect the preference of the cooking oil used, and the way it is used or cooked. Additionally, the consideration of workers' skills and knowledge is important to ensure the production of high-quality products.

a. Use of Raw Materials and Labor

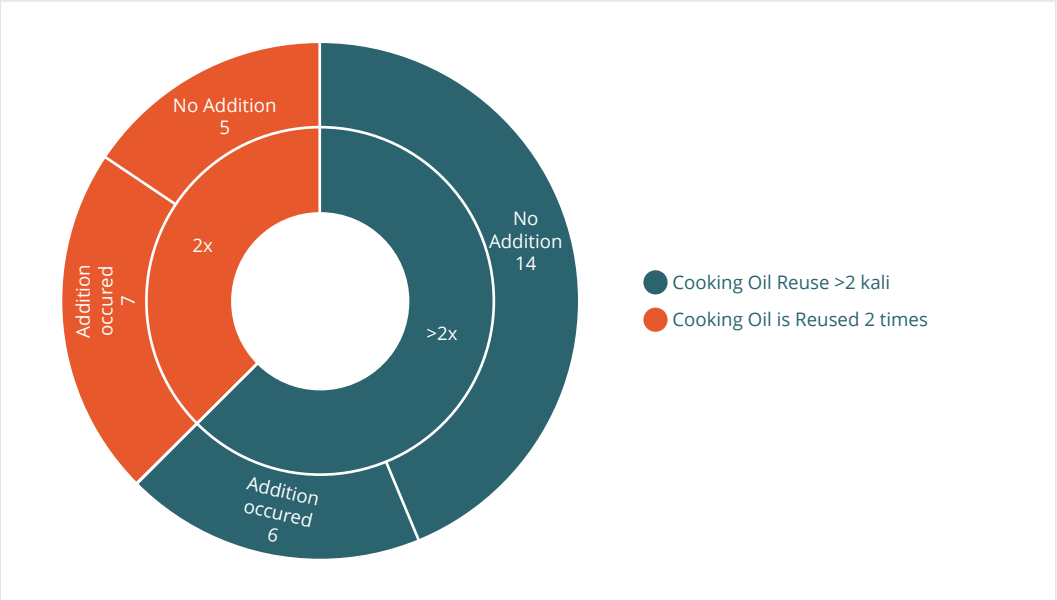
Industry players in the accommodation, food and beverage service activities sector have specific preferences when it comes to using cooking oil. Of the respondents interviewed, only 9% used solid cooking oil and the remaining 91% used liquid cooking oil. Respondents who use solid cooking oil prefer the *deep frying* method, as this type of oil was historically used to ensure product storage stability (Budijanto & Sitanggang, 2010). However, respondents who used the deep frying method did not necessarily use solid cooking oil as their raw material.

Figure 4. The Frying Methods Used by Actors in the Accommodation, Food and Beverage Service Activities Sector (HoReCa)



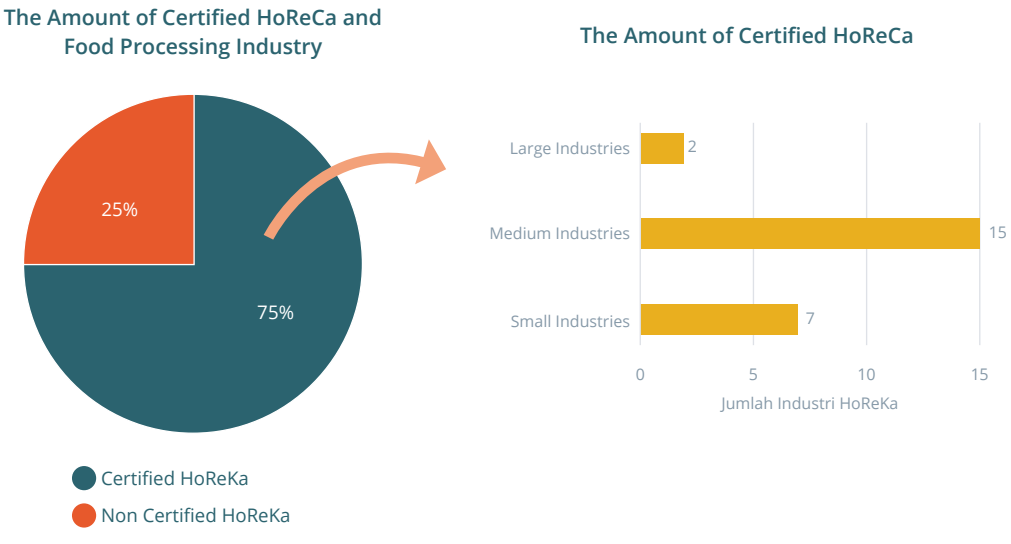
Industry players in the accommodation, food and beverage service activities sector generally use several frying methods to produce their products. The most commonly used method is deep frying, with 94% of respondents employing this method, while the least used method is vacuum frying, with only 3% of respondents utilizing it. Based on the data collected from respondents, the deep frying method is generally used to produce dry foods such as fries, fried chicken, and fried fish. Meanwhile, the shallow frying and sauté frying methods were used by 50% and 63% of respondents, respectively. This frying method is commonly used by accommodation, food and beverage service activities sector providers with a diverse range of products, such as hotels and restaurants that offer stir-fry dishes. Other accommodation, food and beverage service activities sector providers, such as restaurants and cafes that specialize in a single fried product, like fried chicken in restaurants and fries in cafes, typically use just one frying method, namely deep frying which requires a large volume of cooking oil and is often reused for two or more frying cycles.

Figure 5. Frequency of Cooking Oil Use and the Addition of New Oil in the Accommodation, Food and Beverage Service Activities Sector



To streamline production costs, 63% of industry players used cooking oil more than twice, while the remaining 37% only used cooking oil twice for production. The most common reason mentioned by the interviewees is that the cooking oil is still suitable for use, as it appears clear or not too concentrated and has not yet turned black. Interviewees who used cooking oil more than twice also added new cooking oil in varying volumes, ranging from 4% to 67% of the initial volume. Meanwhile, respondents who only used cooking oil twice also mixed it with new oil, with proportions ranging from 8% to 100% of the initial volume. The addition of new cooking oil aims to enhance the quality of the previously used oil (Nur et al., 2014). This is done by chefs who have educational or training backgrounds, as well as by individuals who carry out frying activities in the HoReCa industry.

Figure 6. Certification of Expertise and Total Workforce in the Accommodation, Food and Beverage Service Activities Sector.



In the context of employment, about 75% of respondents revealed that they used workers who had special educational or training backgrounds regarding the production process in the kitchen. In general, medium and large-scale industries employ the highest number of certified workers. The distribution of certified labors ranges from 4 to 24 people per industry player in the food and beverage industry. However, 25% of respondents reported not employing certified workers, with the majority being small-scale industries where production activities involve only 1 to 2 workers. The decision to employ certified workers is often driven by the need to ensure product quality, meet guest or buyer expectations, and provide quality assurance that supports higher sales prices (Wan et al., 2017). This trend is particularly evident in medium and large-scale accommodation, food and beverage service activities sector, which place greater emphasis on product quality and market competitiveness (Rahman et al., 2016).

b. Products Produced and Revenue

The accommodation, food and beverage service activities sector offers a wide range of products to guests and visitors. One of the industries in it, namely hotels, has a variety of products offered, such as lodging accommodation as the main product, as well as room accommodation, food, and entertainment as supporting products. Other industries, such as restaurants and cafes, also offer a variety of products in the form of food and beverage items, including main dishes, vegetables and stir-fries, side dishes, supporting foods, and various beverages. The three industries all produce food products that use cooking oil as a key ingredient in their production activities. Thus, the amount of production and selling price are focused on these products.

Figure 7. Selling Price and Production Quantity in the Accommodation, Food and Beverage Service Activities Sector

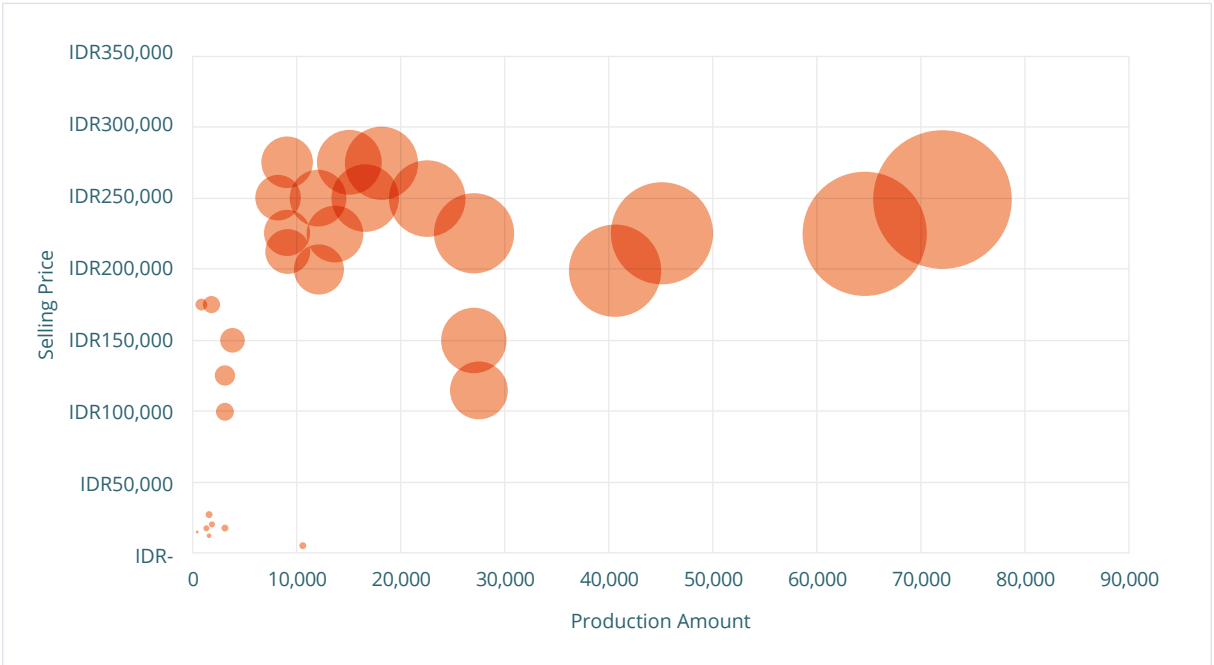


Figure 7 illustrates the distribution of monthly production volume, product selling prices, and the resulting monthly income from these products. There is a notable difference between small-scale and medium to large-scale accommodation, food and beverage service activities sector, particularly in the average selling price of their products. Small industries sell their products at a price range of 10,000 to 150,000 per pax, while medium and large industries sell their products at a price range of 115,000 to 250,000 per pax. With limited production capacity, corresponding to the number of workers employed, and relatively low prices, this results in the revenue generated by small industries fall below medium and large industries. The revenue generated from this production is illustrated by the area of the circle in Figure 7.

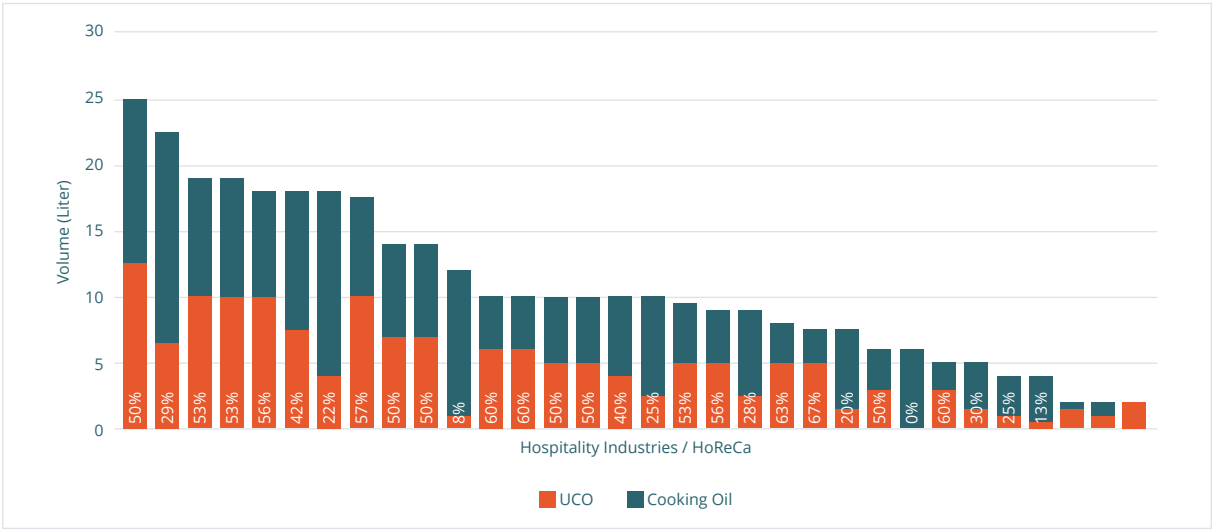
4.2.2. Quantity, Management, and Price of Used Cooking Oil

In the scope of production involving frying activities, the accommodation, food and beverage service activities sector inevitably produces waste cooking oil as a by-product or externality of the activity. The quantity of used cooking oil can be seen or differentiated based on the industrial scale. In general, the larger the industrial scale, the more volume of used cooking oil produced. In the medium and large-scale accommodation, food and beverage service activities sector, there are established standards for managing used cooking oil, including storing it in closed containers, with some even filtering the oil before storage. The filtration of used cooking oil aims to separate the oil from other waste materials, such as flour remnants and pieces of chicken or potatoes that are commonly mixed in (Erlita et al., 2022). However, in the small-scale accommodation, food and beverage service activities sector, some industry players still dispose of the used cooking oil directly at the washing area.

a. Quantity

The volume of cooking oil will certainly not exceed the volume of cooking oil used. But in general, the larger the volume of cooking oil used, the greater the potential volume of used cooking oil produced. This is because the accommodation, food and beverage service activities sector maintains the quality of the products produced and does not reuse used cooking oil more than twice (Rincón et al., 2019).

Figure 8. The Volume of Cooking Oil and Remaining UCO



Used cooking oil remaining from production processes in the accommodation, food and beverage service activities sector averages about 42%. The highest recorded amount left is 75%, while the lowest is 0%. In medium and large-scale HoReCa enterprises, the average remaining oil is approximately 48% -highest 68%, lowest 20%. This contrasts with small-scale enterprises.

The use of cooking oil continues until it is completely depleted. Medium and large-scale enterprises generally manage their resources more efficiently while ensuring the quality of their products. However, with the rising frequency of cooking oil usage - often to the point of leaving no residue - the quality of the cooking products produced is declining. This deterioration can lead to health problems for consumers (BPOM, 2023).

b. Standards Used for Managing Used Cooking Oil

The management of used cooking oil produced by HoReCa industry players is important to analyze because it can affect the selling price of used cooking oil to other parties, namely biofuel producers, the government (Environmental Agency or Waste Bank), and other parties. Most HoReCa industry players (75%) manage their used cooking oil by storing it in dedicated closed containers or its original packaging, such as jerry cans. Meanwhile, 25% of these industry players have yet to manage their used cooking oil, simply placing it in open containers or discarding it outright.

Table 5. UCO Management in Hotel, Restaurant and Cafe (HoReCa) Industry

Have management standards	Has a screening process	Storage	HoReCa Percentage
Yes	Yes	Storage/Enclosed space	6%
Yes	No	Storage/Enclosed space	22%
Yes	Yes	Original packaging	3%
Yes	No	Original packaging	44%
No	No	Storage/Open space	19%
No	No	Discarded	6%
Total			**100% / 32 HoReKa**

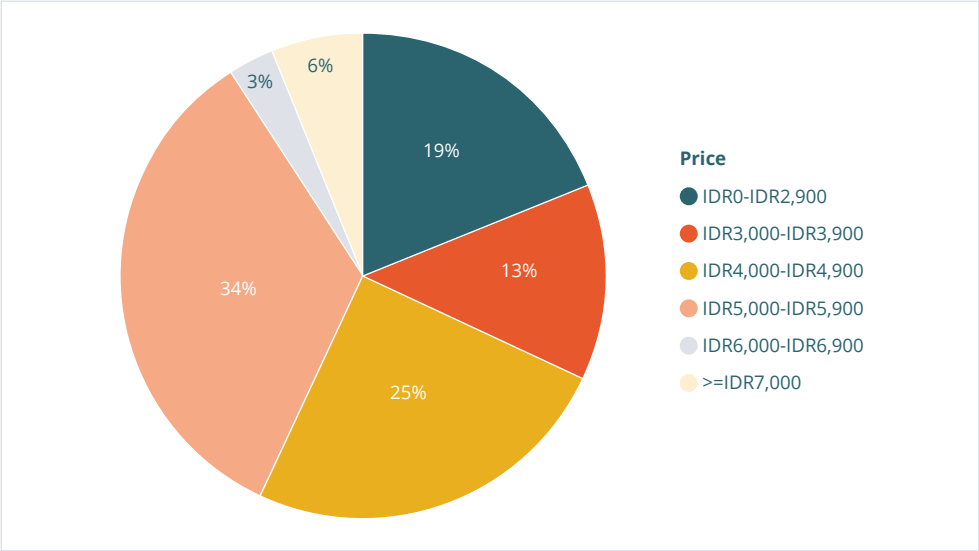
Among the industry players who have managed their used cooking oil, 9% of respondents reported filtering the used cooking oil produced before pouring it into special closed containers or into the original packaging. Overall, 47% of respondents chose to store used cooking oil in its original container, while 28% used a special closed container. Used cooking oil is typically stored in special closed containers such as drums or jerry cans for large volumes, while the original containers usually have a capacity of 18–20 liters. 19% of industry respondents do not manage the used oil and store it in open containers, while 6% dispose of the oil. Used cooking oil stored in open containers can degrade in quality due

to oxidation, leading to the breakdown of triglycerides into glycerol and free fatty acids (Khoirunnisa et al., 2019).

c. Selling Price

In addition to revenue from product sales, the accommodation, food and beverage service activities sector also generates additional income from waste produced during the production process, including used cooking oil. Around 88% of respondents recorded the proceeds from the sale of used cooking oil as additional income. Although the value is not very large, the income from the sale of used cooking oil when compared to the average purchase of cooking oil is 8%, with the highest value reaching 21%. Another reason for accommodation, food and beverage service activities sector players to sell used cooking oil and record it is for reporting on waste management and obtaining certificates for environmentally friendly operations, if they provide their used cooking oil to biofuel producers (Rahmafitria, 2014).

Figure 9. UCO selling price by HoReCa Industry



The price of used cooking oil sold by players in the accommodation, food and beverage service activities sector varies significantly. As illustrated in Figure 10, 34% of the industry sells their used cooking oil for prices between IDR 5,000 and IDR 5,900 per liter, while 25% sell it in the range of IDR 4,000 to IDR 4,900 per liter. This variation indicates a lack of standardized pricing for used cooking oil, suggesting potential competition among buyers in the market.

4.3. Manufacture of Food Products

Unlike the HoReCa industry, the manufacture of food products tends to concentrate on more specific and less diverse products. For example, the instant noodle processing sector primarily produces instant noodles, while the cracker processing sector focuses exclusively on crackers. This specialization aims to minimize production costs by using a single production line, standardized equipment, and a smaller workforce (Smith et al., 2008).

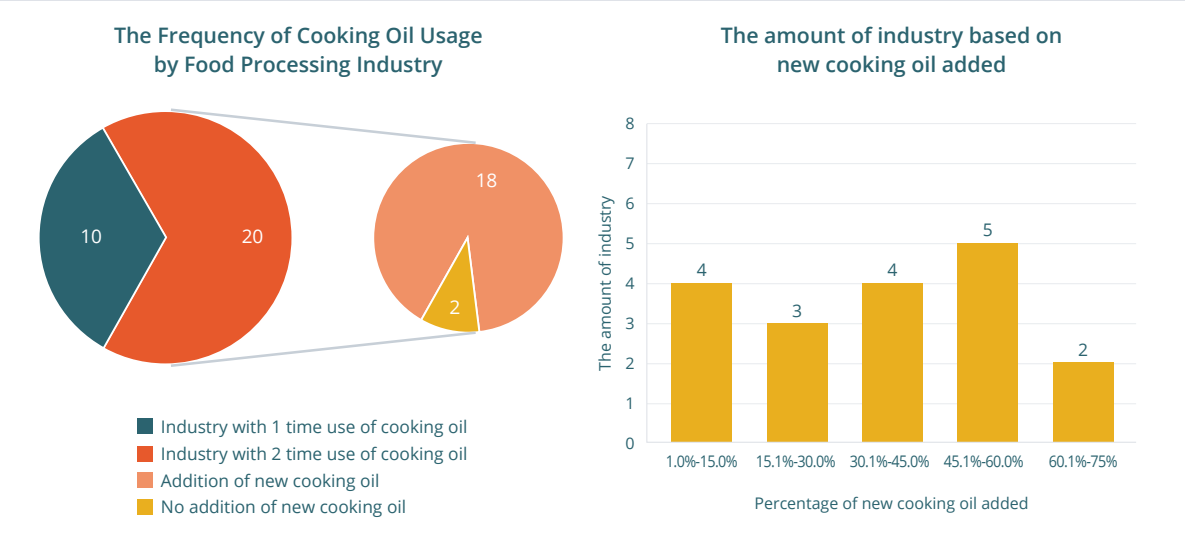
4.3.1. Scope of Production Activities

According to Dorfman (2014), players in the manufacture of food products prioritize profit maximization by reducing production costs, such as raw materials and labor, while boosting revenue through higher product volumes and optimal pricing strategies. Survey results indicate that approximately 67% of respondents in the manufacture of food products reuse cooking oil up to two times during production. Additionally, the average monthly production volume reached 121,820 pieces, highlighting substantial production levels and a significant reliance on input resources.

a. Use of Raw Materials and Labor

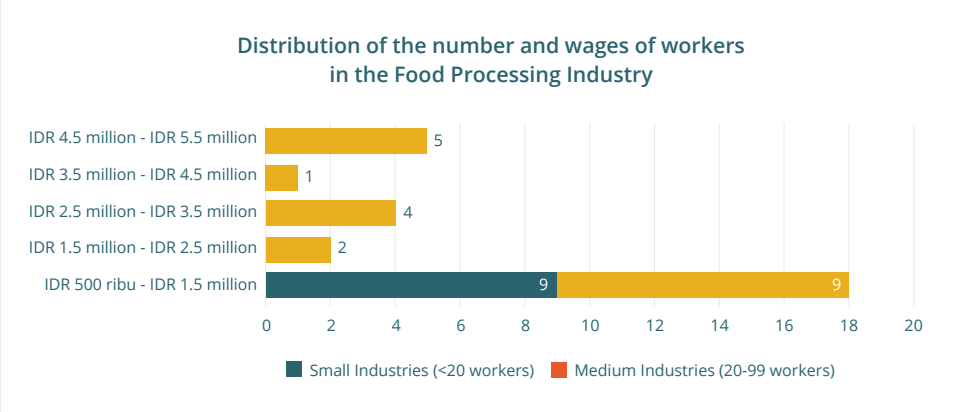
Respondents in the manufacture of food products, whether small, medium or large scale, all use the *deep frying* method to produce products for sale. The manufacture of food products chooses this method because the products produced are dry foods such as crackers, tofu, donuts, and other fried foods. The *deep frying* method will produce food that has dry, crispy properties and a savory taste, so it suits the products of most manufacture of food products.

Figure 10. Frequency of cooking oil use and percentage of new cooking oil added



To maximize the efficiency of raw material usage, approximately 67% of respondents from the manufacture of food products adopted a policy of reusing cooking oil up to two times in their production processes. Among those who reused frying oil twice, about 90% added new cooking oil to the used oil. The amount of new oil added varied, but most respondents typically supplemented the used oil with an additional 24% to 44% of its original volume. This indicates that the addition of new cooking oil during the second frying process is relatively minimal. In deep frying, adding too much new cooking oil can prolong the heating process and increase production costs (Surojanametakul et al., 2020).

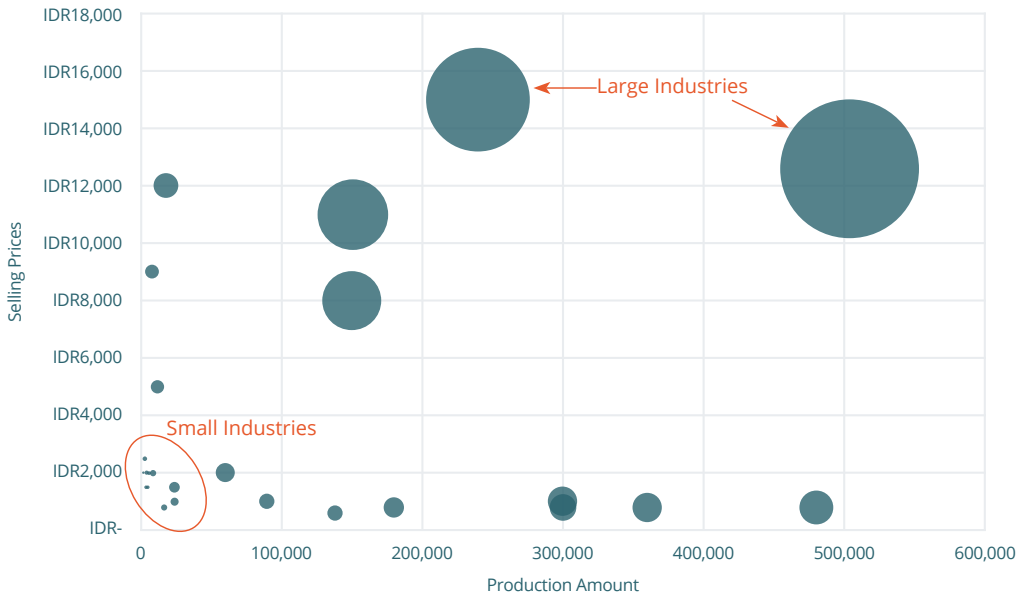
Figure 11. Distribution of the Number and Wages of Workers in the Manufacture of Food Products



According to data collected from respondents in the manufacture of food products, only about 17% indicated that they require certification for the workforce involved in the production process. In contrast, approximately 83% of respondents do not view certification or thorough background checks as necessary for labor in this area.This perspective is due in part to the standard operating procedures (SOPs) that have been adopted within the industry. Those in the manufacture of food products believe that anyone who effectively follows the SOPs can acquire the necessary skills, particularly in frying. As a result, respondents place greater emphasis on understanding and adhering to established procedures, leading to the view that formal certification is less relevant in the frying process within the manufacture of food products.

b. Products Produced and Revenue

Figure 12. Selling Price and Quantity of UCO Produced by the Manufacture of Food Product



The manufacture of food products is a sector that produces a very high number of products, reflecting large production levels to meet market demand. The unit price of products sold by the manufacture of food products is relatively cheaper when compared to the HoReCa industry. Efficiency in the production process and mass use of raw materials are the main factors in keeping prices low (Martusa & Haslim, 2011). The difference between each industry scale can be seen from the production capacity, where large-scale industries can produce a much larger number of products compared to small or medium scale industries.

Large industries can produce a massive number of products within a month, reaching approximately 504,000 pieces. In contrast, small industries have a significantly lower production capacity, ranging from 3,000 to 24,000 products. Medium-sized industries, with an average production of around 150,000 products, have a price range similar to that of small industries, at approximately IDR 2,000 per product.

As illustrated in Figure 12, large industries demonstrate substantial production capabilities and can sell their products at higher prices, resulting in significant revenues. The size of each industry's circle in the illustration represents its revenue—larger circles indicate higher revenues. Thus, large industries are able to produce extensive quantities of products because they have high capital investment, and allow for the construction of larger and more efficient means of production.

4.3.2. Quantity, Management, and Price of Used Cooking Oil

The manufacture of food products produces very little used cooking oil when compared to the HoReCa industry. This is because industry players maximize the resources used to produce maximum products and profits. However, the used cooking oil produced is managed quite well by the manufacture of food products with none of it being thrown away even though some respondents still store it in open containers/places.

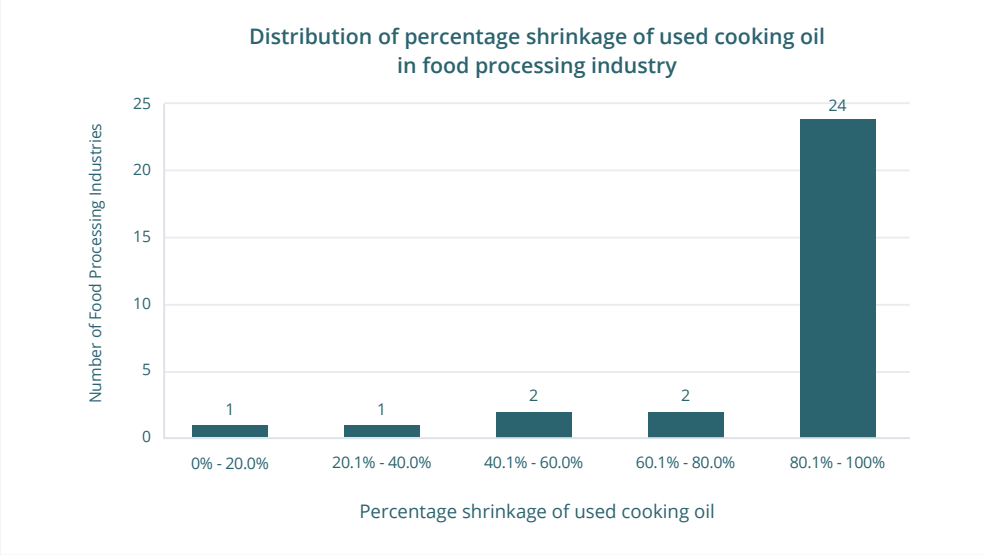
a. Quantity

Used cooking oil produced by the manufacture of food products in each production process ranges from 0.25-20 liters with an average of 2.06 liters. This occurs in all scales of industry, whether small, medium or large scale. In percentage terms, small-scale industries have a smaller loss rate because the volume of used cooking oil produced compared to the cooking oil used is not too far away, which is at least 20% with an average of 74%, while medium and large industries are at least 33% with an average of 92.1%. This means that compared to small industries, medium and large industries utilize cooking oil more optimally, resulting in higher loss rate.

In general, the distribution of the percentage of cooking oil loss used by food processing industry respondents can be seen in Figure 14. A total of 24 respondents used their cooking oil to shrink in the range of 80% to 100% or until it ran out, while the ranges of 20%-40%, 40%-60%, and 60%-80% each had 2 respondents in them. The very high loss rate of cooking oil by the manufacture of food products is possible because all respondents use the *deep frying* method to produce products. This method requires a lot of cooking oil in

hot temperatures and on the other hand, little used cooking oil is produced because it is absorbed by the food. Wai (2007) states that using cooking oil for continuous deep-frying in the same container at a consistent temperature can help maintain the oil's quality.

Figure 13. Used Cooking Oil Loss in Manufacture of Food Products



b. Management Standard

Overall, the manufacture of food products has demonstrated more effective management of used cooking oil, as none of the respondents reported disposing of it directly into drains or on the ground. However, 23% of respondents' store used cooking oil in open containers, exposing it to rainwater contamination. This practice is considered poor management, as the mixture of used cooking oil and rainwater reduces its quality by increasing moisture content, necessitating additional treatment before it can be processed into biofuel.

Table 6. UCO Management by Manufacture of Food Products

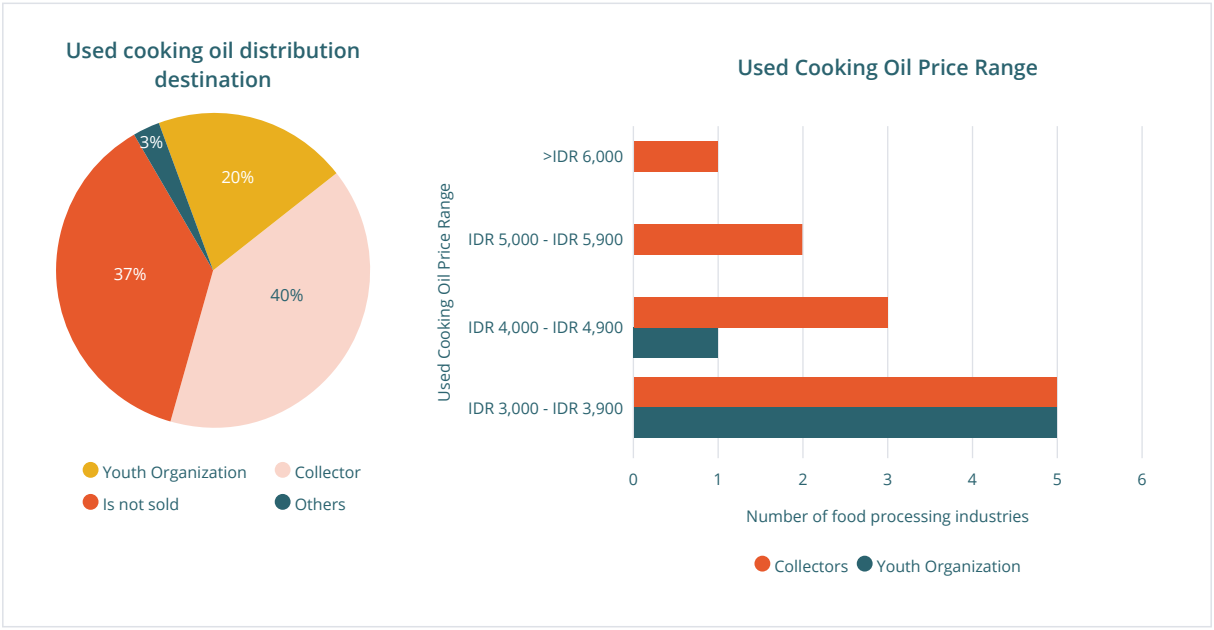
Has management standards	Has a filtering process	Storage area	Percentage of food processing industry
Yes	Yes	Closed container/place	70%
Yes	No	Closed container/place	7%
No	Yes	Open container/place	13%
No	No	Open container/place	7%
No	Yes	Original packaging	3%
Total			**100%/30 Food processing industries**

Table 6 illustrates that respondents who manage their used cooking oil primarily store it in closed containers, such as drums or jerry cans. In contrast, respondents who do not manage their used cooking oil often use open containers or leave it in unsealed original packaging. Notably, some respondents filter the used cooking oil before storage, regardless of the type of container. Among those using closed containers, 70% performed the filtering process, while 16% of those using open containers also filtered their used cooking oil.

c. Selling Price

Used cooking oil generated by the manufacture of food products is typically sold to various parties at different price points. However, 37% of respondents reported not selling their used cooking oil, opting instead to reuse it for household purposes or as adhesive for snack packaging. This behavior may stem from concerns about factors such as price competition in the used cooking oil market or the enforcement of collection regulations in DKI Jakarta Province.

Figure 14. Destination of inbound sales and selling price of UCO by Food Processing Industry



A total of 40% of respondents from the manufacture of food products reported selling their used cooking oil to private collectors at prices ranging from IDR 3,000 to IDR 9,600 per liter. The majority of these respondents, around 46%, sold their used cooking oil to the private sector within the price range of IDR 3,000 to IDR 3,900. Additionally, 20% of respondents sold their used cooking oil to nearby Karang Taruna (Youth Organizations) at a lower price, between IDR 3,000 and IDR 4,900. Among this group, the highest percentage of respondents (83%) sold their used cooking oil at prices between IDR 3,000 and IDR 3,900. Overall, this indicates that the bulk of used cooking oil from the manufacture of food products respondents is sold within the IDR 3,000 to IDR 4,000 price range.

4.4. Estimation of Potential UCO Availability in the Industrial Sector

The potential availability or generation of UCO in the industrial sector is shaped by several factors, primarily the production patterns of industry players. Generally, UCO generation is determined by the volume of cooking oil used and the percentage of loss during production. In the accommodation, food and beverage service activities sector, production patterns are often reflected in the number of kitchens - more kitchens equate to higher cooking oil usage. In contrast, the production pattern in the manufacture of food products is closely tied to its production capacity, with higher capacities leading to greater cooking oil consumption. Additionally, various other variables can influence UCO potential and provide a basis for estimating the volume of UCO generated.

4.4.1. Hotel, Restaurant and Cafe (HoReCa) Industry

The estimation of UCO generation in the HoReCa industry is based on data gathered from respondent interviews, using specific assumptions to support the calculations. These assumptions take into account the distribution of data and the relationships between variables affecting UCO volume. Consequently, the estimation results aim to closely reflect actual conditions or, at the very least, provide a conservative estimate of the minimum UCO volume produced by the HoReCa industry. The key data and assumptions used include:

- Number of accommodation, food and beverage service activities sector (Hotels, Restaurants, and Cafe) in each province in Indonesia (BPS, 2022).
- Number of kitchens of each industry type:
  - Hotel: Each set of 20 rooms is assumed to have one kitchen.
  - Restaurants & Cafes: The number of restaurants & cafes plus 25% of the number.
- Average cooking oil consumption is 540 liters/month per kitchen.
- UCO generation is 48% of the volume of cooking oil used. This assumption is based on the survey results which found that the average used cooking oil residue in each production process in the large and medium scale HoReCa industry is 48%.

Based on this assumption, it can be estimated that the amount of UCO generated annually nationally is 218,871.7 kL. Table 7 shows the details of the estimated volume of UCO generated in each region. The island of Java statistically has the highest number of hotels and restaurants compared to other regions. Furthermore, when viewed in more detail in each province, DKI Jakarta ranks top followed by Bali.

Tabel 7. Potential UCO per-month by HoReCa Industry per region

Region	Numbers of Hotel	Numbers of Resto	Number of Kitchen	Quantity of Cooking Oil (liters/month)	UCO volume liters/ month)
Sumatera	641	1,134	11,168	6,030,504	2,894,642
Jawa	1,682	4,230	34,657	18,714,564	8,982,991
Kalimantan	346	338	5,364	2,896,560	1,390,349
Sulawesi	330	296	4,472	2,414,772	1,159,091
Bali-Nusra	574	389	13,129	7,089,606	3,403,011
Maluku-Papua	126	74	1,579	852,552	409,225
Total	3,699	6,461	70,368	37,998,558	**18,239,308**

The potential for UCO generation in the HoReCa industry is primarily concentrated in provinces with large cities and high tourism activity. In Sumatra, North Sumatra has the highest UCO potential, with 4.6 million tourist visits recorded in 2022 - more than any other province on the island. Similarly, in Sulawesi, South Sulawesi leads in both tourist visits and UCO potential (Figure 15). This correlation suggests that provinces with higher tourism activity, as indicated by Amir et al. (2017), tend to have a greater number of HoReCa establishments and, consequently, higher UCO generation, reflecting the increased demand for hotels, restaurants and cafes.

Figure 15. Distribution of potential UCO volume per-month by HoReCa Industry by province

4.4.2. Manufacture of Food Products

As with the HoReCa industry, the calculation of UCO estimation in the manufacture of food products also uses data from interviews with respondents which uses several assumptions as a basis for calculation. Some of the assumptions used are:

- Number of manufacture of food products that use cooking oil as raw material, in each province in Indonesia (BPS, processed, 2023)
- Volume of cooking oil used in the processing industry, in each province. (BPS, processed, 2023)
- UCO generation is 25% of the volume of cooking oil used. This assumption is based on survey results which found that the average cooking oil residue in each production process in the manufacture of food products is 25%.

Based on this assumption, it can be estimated that the volume of used cooking oil (UCO) produced annually by the manufacture of food products throughout Indonesia reaches 714,296.6 kL. Details of the estimated UCO volume by region are shown in Table 6. Potential UCO per month by manufacture of food products per region. Statistically, the island of Java has the highest number of hotels and restaurants compared to other regions. Furthermore, when analyzing the detail for each province, West Java has the highest UCO volume, followed by East Java and Central Java.

Table 8. Results of the analysis of variables affecting the volume of UCO in the Food Processing Industry

Variables	Coef	Std, Error	t	p-value	[0,025	0,975]
Const,	15,9212	30,426	0,523	0,605	-46,621	78,463
Number of Workers	4,0170	1,462	2,747	0,011	1,012	7,022
Revenue	3,22e-08	1,9e-08	1,691	0,103	-6,95e-09	7,13e-08
Production Capacity	-0,0005	0,000	-2,416	0,023	-0,001	-7,52e-05

The production potential of UCO in the manufacture of food products is generally concentrated in Java, with Lampung Province in Sumatra ranking fifth after West Java, East Java, Central Java, and Banten in terms of UCO production (Lopez & Henderson, 1989). The location of the manufacture of food products is strongly influenced by the presence of markets and existing infrastructure. The substantial market presence and consumer base in Java have led to the notable presence of the manufacture of food products in these provinces, which potentially contributes to a higher UCO production.

Furthermore, geophysical factors, such as the availability of suitable land and labor, play a crucial role in determining the location of the manufacture of food products, as explained by Kilang Permatasari (2020). These two factors influence the limited number of manufacture of food products in the provinces of DKI Jakarta and DI Yogyakarta, where the availability of affordable land and labor is often incompatible with the financial capabilities of industry players.

Figure 16. Distribution of potential UCO volume per-month by Manufacture of Food Products per province

4.4.3. Interventions to Increase UCO Volumes in the HoReCa and Manufacture of Food Products

The HoReCa industry is not only limited to food manufacturing, but also involves the provision of various services such as accommodation, entertainment, and so on. Due to its complex characteristics, in an effort to increase the volume of UCO, it is necessary to identify which variables have the greatest influence on the volume of UCO produced. The variables considered in the context of the HoReCa industry include cooking oil volume, number of workers, total revenue, number of rooms, and number of *kitchens*. Based on the partial regression analysis results listed in Table 7, the variable that has a p-value <0.05 is the number of *kitchens*, which means it has a significant influence on the volume of UCO produced.

Table 9. Results of analysis of variables that affect the volume of UCO in HoReCa Industry

Variable	Coef	Std. Error	t	p-value	[0.025	0.975]
Const.	2,9136	38,053	0,077	0,940	-75,306	81,133
Number of Workers	0,6852	1,206	0,568	0,575	-1,793	3,164
Income	6,515e-10	5,39e-09	0,121	0,905	-1,04e-08	1,17e-08
Number of Rooms	-0,1928	0,177	-1,092	0,285	-0,556	0,170
Total Kitchen	66,1066	22,248	2,971	0,006	20,375	111,838

Meanwhile, the manufacture of food products has different characteristics from the HoReCa industry. This industry usually produces a limited number of products and is segmented. In identifying the factors that influence several variables can be considered, including the number of workers, income, and production capacity. Based on the results of the partial regression analysis recorded in Table 8, the variables that have a p-value <0.05 are the number of workers and production capacity, indicating that these two variables significantly affect the volume of UCO produced.

Tabel 10. Results of the analysis of variables affecting the volume of UCO in the Food Processing Industry

Variables	Coef	Std, Error	t	p-value	[0,025	0,975]
Const,	15,9212	30,426	0,523	0,605	-46,621	78,463
Number of Workers	4,0170	1,462	2,747	0,011	1,012	7,022
Revenue	3,22e-08	1,9e-08	1,691	0,103	-6,95e-09	7,13e-08
Production Capacity	-0,0005	0,000	-2,416	0,023	-0,001	-7,52e-05

4.5. UCO Collection Model in the Industrial Sector

After evaluating the value and distribution of potential UCO in the HoReCa industry and manufacture of food products, the next step is to establish a UCO collection model from industry players. The importance of formulating this collection model is because it can have an impact on operational costs and environmental impacts, especially related to greenhouse gas emissions. As analyzed by Traction Energy Asia (2023), an efficient collection model has the potential to reduce greenhouse gas emissions resulting from the production of UCO-based biofuels. Therefore, selecting an appropriate collection model will be a key step in minimizing environmental impacts while maximizing operational efficiency in the food processing industry and HoReCa sector.

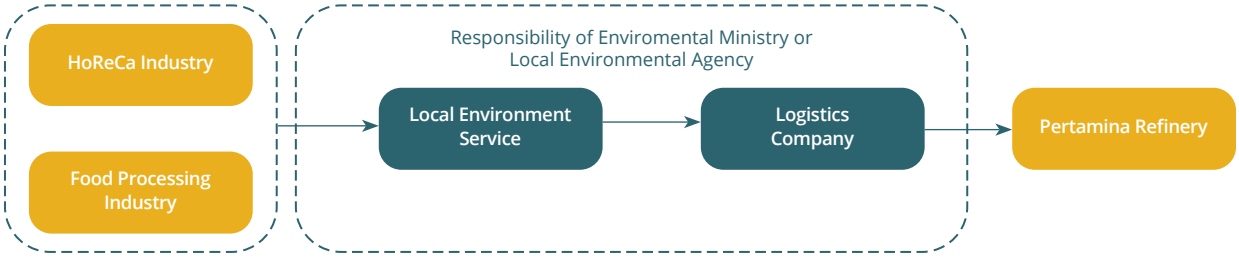
Interviews with industry respondents revealed that UCOs from industry players are generally handed over to three parties: the local environmental agency, private collectors, and community organizations such as Karang Taruna and waste banks. The more complex the distribution chain in this collection model, the more likely the final price of UCO will increase due to the additional operational and logistics costs of each actor involved in the collection process. The development of this collection model is predicated on the assumption that the collected UCO will be processed at the Pertamina Refinery, a factor that must be taken into account when determining the logistics and distribution costs of the UCO collection system.

4.5.1. Collection Model of Local Environmental Agencies

UCO collection by local environmental agencies offers a number of advantages that not only support more effective environmental monitoring and regulation, but also promote increased public awareness, especially among industry players, on the importance of

responsible UCO waste management. Such initiatives have the potential to reduce the risk of environmental pollution while ensuring that UCO collection, transportation and processing are carried out in accordance with applicable standards. By promoting an integrated approach, involving various stakeholders such as the government, the HoReCa industry, processing food, and UCO processors, it can create a UCO management system that is not only efficient but also effective.

Figure 17. UCO Collection Model by the Local Environmental Agencies



However, there are a number of challenges that need to be overcome, including the limited resources and capacity of local environmental agencies. This includes financial and human resource challenges to manage a wider scale of UCO collection programs. Budgetary issues are a major challenge due to the transactional nature of the UCO collection scheme and the fact that it is paid on the spot. In this case, the local Environmental Agency must have a dedicated budget to run the UCO collection. In addition, the development and maintenance of safe and efficient logistics and storage infrastructure requires significant investment.

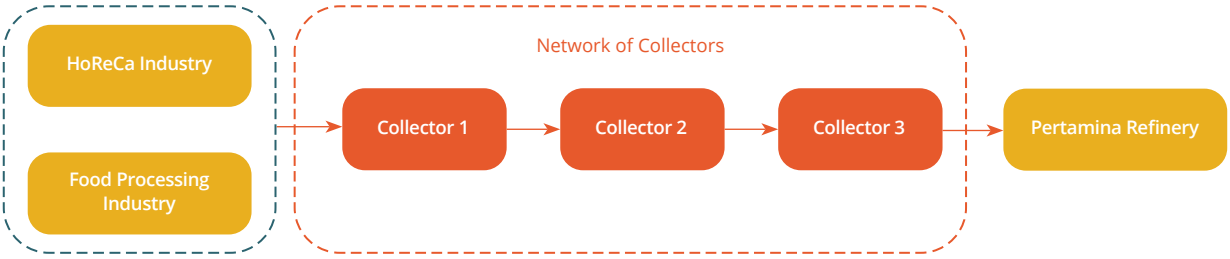
Considering these challenges, the success of this scenario depends on several key factors, namely the development of clear regulations, the establishment of strategic partnerships between the public and private sectors, proper investment in infrastructure, budget allocation, and outreach and effective education campaigns. Through strong commitment from all parties and adequate resource support, the potential of implementing UCO collection by local environmental agencies in the HoReCa and manufacture of food products can be realized, supporting environmental sustainability while increasing renewable energy production.

4.5.2. Collection Model from Collectors (Private)

The collection of used cooking oil (UCO) by private collectors offers operational efficiency and increased flexibility in its management. With established logistics systems and the capability to handle large quantities of UCO, these private collectors provide effective collection solutions for the HoReCa (Hotels, Restaurants, and Cafe) and manufacture of food products.

These advantages stem from the collectors' ability to innovate in UCO collection and processing methods, supported by a profitable business model that creates strong economic incentives for all parties involved. By implementing this approach, the HoReCa and manufacture of food products can streamline their waste management processes, potentially generate additional revenue, and promote environmental sustainability efforts.

Figure 18. UCO collection model by collectors (private)



However, the scenario of private collection of UCOs also brings challenges. Controls and standards for UCO collection and processing may be reduced in the absence of adequate regulation and oversight, posing risks to quality and compliance with environmental standards. Market dynamics affecting UCO prices can cause significant fluctuations, potentially reducing incentives for sustainable UCO collection and processing. In addition, collectors may potentially prefer to work with large-scale UCO producers, which could leave small businesses with fewer options for the management of their UCOs.

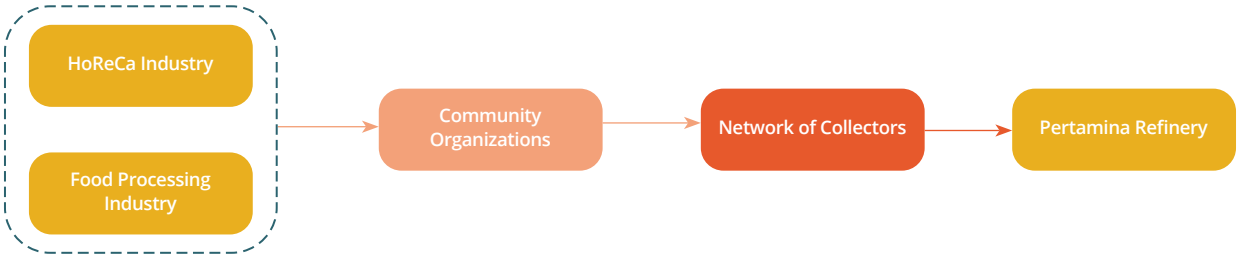
The purchase price of UCO by private collectors requires careful business analysis. Aspects such as cost structure, final product selling price, availability of government incentives or subsidies, and ability to negotiate with UCO producers will determine the feasibility of this price. The collector should consider market dynamics and potential profit margins to ensure that the purchase of UCO at this price is still profitable. Strategies that can be adopted include building long-term relationships with UCO producers and utilizing government incentives for renewable energy, which can help balance costs and maintain a sustainable business model.

4.5.3. Collection Model from Community Institutions (Waste Bank and Karang Taruna)

The collection of used cooking oil (UCO) by community organizations, such as waste banks and youth organizations (Karang Taruna), provides a valuable opportunity to enhance community awareness and participation, particularly within the HoReCa (Hotel, Restaurant, and Café) and manufacture of food products regarding responsible UCO waste management. By focusing on educational and awareness campaigns, these organizations can promote sustainable and environmentally friendly UCO collection practices.

This community-based approach not only helps support the local economy through job creation but also reinforces sustainability values within the community. However, challenges such as limited resources, operational scale, and collection efficiency need to be addressed through effective strategies and collaboration. Additionally, this collection model relies on collectors to transport the gathered UCO to the final processing party, which in this case is the Pertamina Refinery, as community organizations often lack the necessary resources for this task.

Figure 19. UCO collection model by community organizations (Waste Bank, Karang Taruna, etc.)



To overcome this challenge, community organizations can implement non-monetary strategies for collecting Used Cooking Oil (UCO). For instance, they can introduce point-based incentives or rewards to motivate participation without requiring direct financial transactions. This approach would not only appeal to the HoReCa and manufacture of food products but also attract individuals who can exchange points for useful goods or services.

Additionally, raising awareness about the environmental and health benefits of proper UCO management can serve as a strong motivation for participation. By forging strategic partnerships with local governments and other organizations, community agencies can enhance the reach and impact of their UCO collection programs, creating a system that is effective, sustainable, and inclusive for all parties involved.

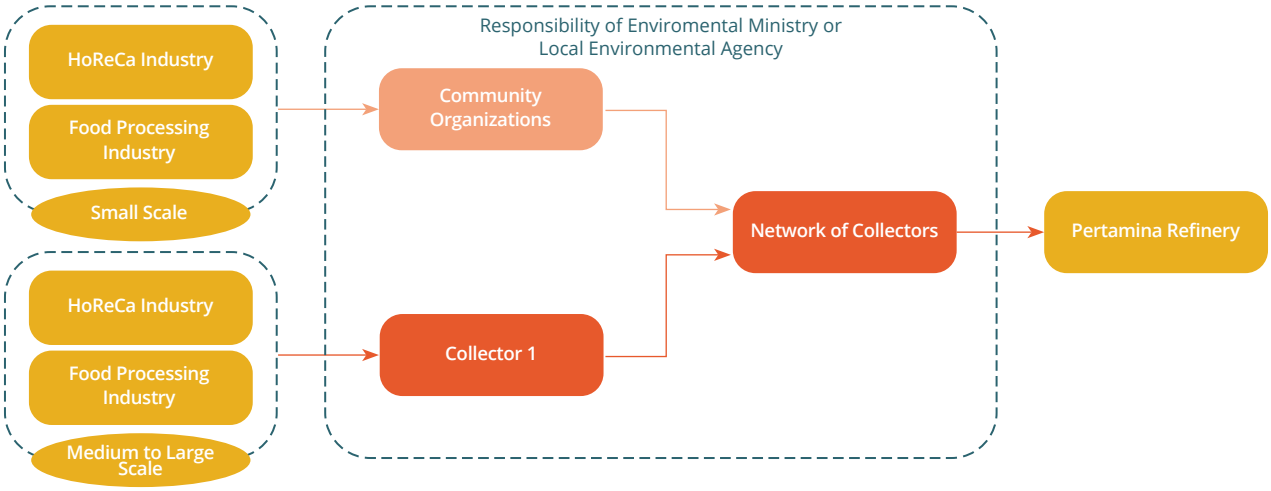
4.5.4. Collection Model Recommendations

The UCO collection model integrates the roles of community organizations, private collectors, and local environmental agencies into a comprehensive and efficient system. Community organizations are responsible for collecting used cooking oil (UCO) from small and medium enterprises in their area, leveraging their established relationships and trust within the local community.

Once collected, the UCO is sold to private collectors who have more logistical capacity and are tasked with sourcing UCO from medium to large enterprises. Additionally, the local environmental agency establishes regulations for UCO collection, appoints authorized collectors, and conducts supervision and assessment of the overall collection system.

The advantage of this collection model is the optimization of resources and competencies possessed by various parties. Community organizations, with their strength in education and local outreach, can raise awareness and participation of communities and small industries in UCO management. Collectors, with their large logistics capacity, ensure efficient collection and transportation of UCOs. Meanwhile, the environmental agency ensures that the entire process complies with applicable standards and regulations, maintaining UCO quality and reducing environmental risks. However, this model also has its drawbacks, including the complexity of coordination between various parties, potential conflicts of interest, and the need for clear and comprehensive regulations. Complex coordination can hamper operational efficiency, while conflicts of interest, especially about the purchase price of UCO, can reduce the incentive for UCO producers to participate. In addition, without clear regulations, the collection system may face legal uncertainties that hamper operational sustainability.

Figure 20. Ideal multi-stakeholder UCO collection model



To address the shortcomings, clear regulations on responsibilities, quality standards for UCOs, and transparent pricing mechanisms are needed. These should ensure fairness for community organizations, collectors, and UCO producers. Fixing a ceiling on UCO purchase prices by environmental agencies could promote equity among producers and organizations while helping collectors manage production costs. Additionally, ongoing education about the environmental and economic benefits of sustainable UCO collection can boost community engagement and support.

The current model of UCO collection in Indonesia reflects a diversity of approaches, where UCOs from industry players are often handed over to several different parties, such as local environmental agencies, private collectors or community organizations as can be seen in Table 9. However, in order to improve the efficiency and effectiveness of collection, it is recommended to develop a model that involves more parties, such as industry, government and community organizations. To achieve the ideal collection model, concrete steps need to be taken, including the establishment of clear and comprehensive regulations governing aspects such as collection, transportation, and processing of UCOs. In addition, a joint commitment from all involved parties are necessary to implement an effective and sustainable collection model.

Tabel 11. Approaches, advantages, and disadvantages of each UCO collection scenario

Scenario	Actor	Collection Approach	Pros	Disadvantages
1	Local Environmental Agency	Mandatori Regulasi	Supervision and regulation Increased community awareness Flexibility and innovation Economic incentives.	Resources and capacity, industry involvement, logistics and infrastructures.
2	Private Collector	Transactional	Operational efficiency, flexibility and innovation, economic incentives.	Controls and standards, dependance on market, access and fairness.
3	Community Organization (Waste Bank and Karang Taruna)	Voluntaristic and Education	Increased community awareness and participation, supporting local economy, community-based approach	The limitation of source, power, scale, and efficiency, continuity and sustainability.
4	Community Institutions, Collectors, Environmental Agency	A combination of mandatory regulation, transactional, and voluntaristic approaches with education.	Optimization of resources and competencies, increased coverage and collection efficiency, as well as improved supervision and control.	Complex coordination, potential conflict of interests, the needs of clear regulation.

4.6. Conclusion

Based on the results and analysis described in the previous section, the potential and model for UCO collection in the industrial sector are as follows:

- The estimated potential of used cooking oil (UCO) in the industrial sector is approximately 933,168.3 kL, comprising 218,871.7 kL for the HoReCa sector at, and 714,296.6 kL for the manufacture of food products. at.
- UCO availability in the industrial sector is generally influenced by production patterns and the scale of business carried out by each type of industry In the HoReCa industry it is most influenced by the number of kitchens available, while in the manufacture of food products it is more influenced by the number of workers and production capacity.
- The loss rate that occurs in the HoReCa industry is 52%, which means that from 1 liter of cooking oil used, 480 ml of used cooking oil will remain, and in the food processing industry has a loss rate of 75%, which means that from 1 liter of cooking oil used, 250 ml of used cooking oil will remain.
- In general, HoReCa industry players have not done much UCO management compared to the manufacture of food products.
- UCO prices in the HoReCa industry are mostly in the range of IDR 5,000 - IDR 5,900, while those in the manufacture of food products are in the range of IDR 3,000 - IDR 3,900.
- UCO generated by HoReCa and manufacture of food products are handed over to three main actors, namely community organizations, collectors (private), and local environmental agencies.

References

Amalia, F., & Rahmayani Johan, I. (2010). PERILAKU PENGGUNAAN MINYAK GORENG SERTA PENGARUHNYA TERHADAP KEIKUTSERTAAN PROGRAM PENGUMPULAN MINYAK JELANTAH DI KOTA BOGOR Analysis of the Behaviour Effects in Using Cooking Oil on the Participation Program of Collecting the Used Cooking Oil in Bogor City. In *Jur. Ilm. Kel. & Kons* (Vol. 3, Issue 2).

Amir, S., Mohamed Osman, M., Bachok, S., Ibrahim, M., & Zen, I. (2017a). *COMMUNITY-BASED TOURISM IN MELAKA UNESCO WORLD HERITAGE AREA: A SUCCESS IN FOOD AND BEVERAGE SECTOR?* (Vol. 15).

Asthasari, R. U. (2008). *KAJIAN PROSES PEMBUATAN BIODIESEL DARI MINYAK JELANTAH DENGAN MENGGUNAKAN KATALIS ABU TANDAN KOSONG SAWIT*. Institut Pertanian Bogor.

Badan POM. "Kajian Keamanan Penggunaan Minyak Jelantah / Used Cooking Oil (UCO)". Bahan paparan pada kegiatan FGD Telaah Teknokratik Naskah Akademik Tata Kelola dan Tata Niaga UCO pada 12 April 2023.

Badan Pusat Statistik. (2023). *Statistik Objek Dayatarik Wisata 2022*.

Badan Pusat Statistik. 2010. Peraturan Kepala Badan Pusat Statistik Nomor 37 Tahun 2010 Tentang Klasifikasi Perkotaan dan Perdesaan di Indonesia: Buku II Jawa. Jakarta: Badan Pusat Statistik.

Badan Pusat Statistik. 2019. "Statistik Lingkungan Hidup Indonesia 2019: Hutan dan Perubahan Iklim". Report. Jakarta: Badan Pusat Statistik.

Bali Portal News. (2022, 30 April). *Warga Panjer Tukar Minyak Jelantah di TPS3R Paku Sari, per Liter Dihargai Rp 5.000*. Diakses pada 2 April 2023, dari https://baliportalnews.com/2022/04/warga-panjer-tukar-minyak-jelantah-di-tps3r-paku-sari-per-liter-dihargai-rp5-000/.

BPS. (2022). *STATISTIK HOTEL DAN AKOMODASI LAINNYA DI INDONESIA*.

BPS. (2023). *Statistik Penyedia Makan Minum 2022*.

Budijanto, S., & Sitanggang, A. B. (2010). Kajian Keamanan Pangan Dan Kesehatan Minyak Goreng. *PANGAN*, *19*(4), 361–372.

Budiyoko, Risa Utami, D., Prasetyo, K., Aptika Rachmah, M., & Adhi Saputro, W. (2022).

Limbah menjadi Faedah: Pengaruh Penyuluhan Terhadap Perubahan Perilaku Ibu Rumah Tangga dalam Pemanfaatan Minyak Jelantah. *Journal of Agricultural Socio-Economic and Agribusiness (JASEA)*, *1*(1), 21–29.

De Vaus, D.A. 2002. Surveys In Social Research 5th Edition. Crows Nest NSW: Allen & Unwin.

Delzeit, Ruth., Tobias Heimann, Franziska Schuenemann, Mareike Soeder . 2019. "Using Used Cooking Oil (Minyak jelantah) For Biofuel Production: Effects On Global Land Use And Interlinkages With Food And Feed Production". Conference Paper. 22nd Annual Conference on Global Economic Analysis In Warsaw, Poland June 19-21, 2019.

Dorfman, Jeffrey H. (2014). *Economics and management of the food industry*. New York, USA: Routledge, Taylor & Francis Group.

Erlita, D., Puspitasari, A., & Pratama, A. R. (2022). Inovasi Penjernihan Minyak Goreng Bekas dengan Alat Purification Oil. *Jurnal Ilmiah Universitas Batanghari Jambi*, *22*(2), 892. https://doi.org/10.33087/jiubj.v22i2.2033

Erviana, V. Y., Suwartini, I., & Mudayana, A. (2018). Pengolahan Limbah Minyak Jelantah dan Kulit Pisang Menjadi Sabun. *Jurnal SOLMA*, *7*(2), 144. https://doi.org/10.29405/solma.v7i2.2003

Ginet, Carl. [1975]. 2004. *Knowledge, Perception and Memory*. Ithaca, New York: Cornel University.

Hadiguna, R. A., & Putra, D. (2015). *DINAMIKA JARINGAN RANTAI PASOK BIODIESEL DARI MINYAK GORENG BEKAS (Analisis, Pemodelan dan Kebijakan)*. Andalas University Press. www.mondoforex.com

Haryono, Sirin Fairus, Yavita Sari, Ika Rakhmawati. 2010. "Pengolahan Minyak Kelapa Sawit Bekas Menjadi Biodiesel: Minyak Goreng Bekas Dari KFC Dago Bandung". Makalah Prosiding. Seminar Nasional Teknik Kimia "Kejuangan" Pengembangan Teknologi Kimia Untuk Pengolahan Sumber Daya Alam Indonesia. Yogyakarta, 26 Januari 2010Math, M.C., Sudheer Pram Kumar, dan Soma V. Chetty. 2010. "Technologies for Biodiesel Production from Used Cooking Oil". Journal of Energy for Sustainable Development, No 14, 2010 hlm 339-345.

Kardes, Frank R., Maria L. Cronley, Thomas W. Cline. *Consumer Behavior*. Mason, OH: South-Western Cengage Learning.

Kementerian Energi dan Sumber Daya MIneral. 2019. "Handbook of Energy and Economic Statistics of Indonesia". Annual Report. Jakarta: Kementerian Energi dan Sumber Daya Mineral.

Kementerian PPN/Bappenas. (2023). *Perkembangan Ekonomi Indonesia dan Dunia*.

Khairunnisa, S., Gusnandi, D., & Sumarsih, U. (2022). Penerapan Standar Operasional Prosedur Kitchen Departemen Di Grand Tebu Hotel Bandung. *E-Preceeding of Applied Science*, 819–825.

Kharina, Anastasia., Stephanie Searle, Dhita Rachmadini, A. Azis Kurniawan, Abi Prionggo. 2018. The Potential Economic Health and Greenhouse Gas Benefits of Incorporating MINYAK JELANTAH into Indonesia's Biodiesel. White Paper. Washington DC: International Council on Clean Transportation (ICCT).

Khoirunnisa, Z., Setya Wardana, A., Rauf, R., Studi Ilmu Gizi, P., Ilmu Kesehatan, F., Muhammadiyah Surakarta Jl Ahmad Yani, U., & Tengah, J. (2019). ANGKA ASAM DAN PEROKSIDA MINYAK JELANTAH DARI PENGGORENGAN LELE SECARA BERULANG. In *Jurnal Kesehatan* (Vol. 12, Issue 2).

Kompas. (2022, 2 Juni). *Enam Aksi Ubah Sampah Jadi Tuah*. Diakses pada 7 April 2023, dari https://www.kompas.id/baca/nusantara/2022/06/01/enam-aksi-ubah-sampah-jadi-tuah.

Kristiana, T., Baldino, C., & Searle, S. (2022). *An estimate of current collection and potential collection of used cooking oil from major Asian exporting countries*. www.theicct.org

Kumparan. (2021, 10 Februari). *Manfaatkan Bank Sampah Induk Surabaya, Bisa Dapat Uang, Sampah Berkurang*. Diakses pada 2 April 2023, dari https://kumparan.com/beritaanaksurabaya/manfaatkan-bank-sampah-induk-surabaya-bisa-dapat-uang-sampah-berkurang-1v9IHxXWFYJ/3.

Kusumaningtyas, Ratna Dewi., Nur Qudus, Rr. Dewi Artanti Putri, Rini Kusumawardani. 2018. "Penerapan Teknologi Pengolahan Limbah Minyak Goreng Bekas Menjadi Sabun Cuci Piring Untuk Pengendalian Pencemaran Dan Pemberdayaan Masyarakat". Abdimas Vol. 22 No. 2, December 2018.

Lopez, R. A., & Henderson, N. R. (1989). *The Determinants of Location Choices for Food Processing Plants**.

Martusa, R., & Haslim, H. D. (2011). PERANAN ANALISIS BIAYA KUALITAS DALAM MENINGKATKAN EFISIENSI BIAYA PRODUKSI (Studi Kasus pada PTP Nusantara VIII Kebun Ciater). *Akurat Jurnal Ilmiah Akuntansi*, *2*(4), 1–20.

Nur, L., Sari, I., Nurlita, F., & Maryam, S. (2014). ANALISIS KUALITAS MINYAK GORENG YANG DIGUNAKAN PEDAGANG AYAM GORENG KAKI LIMA DI SINGARAJA. *Kimia Visvitalis*, *2*(1), 99–106.

Osborne, M. J., & Rubinstein, A. (2020). *Models in Microeconomic Theory*. Open Book Publishers. https://doi.org/10.11647/OBP.0211

Pemerintah Kabupaten Hulu Sungai Utara. (2020, 26 Agustus). *Bank Sampah "Buncu Elha" Kini Terima Pembelian Minyak Jelantah*. Diakses pada 2 April 2023, dari https://web.hsu.go.id/bank-sampah-buncu-elha-kini-terima-pembelian-minyak-jelantah/.

Peraturan Kepala Badan Pusat Statistik Nomor 37 Tahun 2010 Tentang Klasifikasi Perkotaan dan Perdesaan di Indonesia.

Prasetyo, J. (2018). STUDI PEMANFAATAN MINYAK JELANTAH SEBAGAI BAHAN BAKU PEMBUATAN BIODIESEL. *Jurnal Ilmiah Teknik Kimia UNPAM*, *2*(2), 1–10.

Rahmafitria, F. (2014). ECO-RESORT DAN GREEN HOTEL DI INDONESIA : MODEL SARANA AKOMODASI YANG BERKELANJUTAN. *Jurnal Manajemen Resort & Leisure*, *11*(2), 1–22.

Rahman, A. F., Triyantoro, A., & Suradi. (2016). Pengaruh Kualitas Produk Dan Pelayanan Terhadap Kepuasan Konsumen Serta Dampaknya Terhadap Keputusan Konsumen Menginap Kembali. *Jurnal Khasanah Ilmu*, *7*(1), 61–66.

Rincón, L. A., Cadavid, J. G., & Orjuela, A. (2019). Used cooking oils as potential oleochemical feedstock for urban biorefineries – Study case in Bogota, Colombia. *Waste Management*, *88*, 200–210. https://doi.org/10.1016/j.wasman.2019.03.042

Saguy, I. S., & Dana, D. (2003). Integrated approach to deep fat frying: engineering, nutrition, health and consumer aspects. *Journal of Food Engineering*, *56*, 143–152. www.elsevier.com/locate/jfoodeng

Santoso, N. I., Sugiarti, T., & Arisandi, A. (2022). Strategi Pemberdayaan Masyarakat Dalam Pemanfaatan Limbah Minyak Jelantah Di Kelurahan Sambikerep Kecamatan Sambikerep Kota Surabaya. *Amalee: Indonesian Journal of Community Research and Engagement*, *3*(2), 377–391. https://doi.org/10.37680/amalee.v3i2.2035

Smith, D., Spalding, M. A., & Gould, R. J. (2008). Selecting equipment to minimize production costs and maximize profitability. *Journal of Plastic Film and Sheeting*, *24*(1), 21–33. https://doi.org/10.1177/8756087907087171

Suharyanto, Herlina, Rl., & Tugiyono, J. (2021). PENENTUAN TINGKAT PERSEDIAAN OPTIMAL BAHAN BAKU PRODUKSI KERUPUK PADA UMKM X BANDUNG BARAT. *TEDC*, *15*(3), 263–272.

Surojanametakul, V., Karnasuta, S., & Satmalee, P. (2020). Effect of oil type and batter ingredients on the properties of deep-frying flakes. *Food Science and Technology (Brazil)*, *40*, 592–596. https://doi.org/10.1590/fst.32919

Traction Energy Asia. (2022). Identifikasi Potensi Ketersediaan dan Model Pengumpulan Minyak Jelantah dari Rumah Tangga dan Usaha Mikro untuk Bahan Baku Biodiesel: Studi Lima Kota di Pulau Jawa dan Bali. Jakarta: Yayasan Transformasi Energi Asia.

Traction Energy Asia. (2022). *Minyak Jelantah sebagai Bahan Baku Biodiesel Generasi Kedua*. Jakarta: Traction Energy Asia

Traction Energy Asia. 2019. "Emisi Gas Rumah Kaca dari Produksi Biodiesel di Indonesia Berdasarkan Analisa Daur Hidup (Life Cycle Analysis)". Working Paper. Jakarta: Traction Energy Asia.

Wai, T. N. K. (2007). Local Repeatedly-Used Deep Frying Oils Are Generally Safe. *IeJSME*, *1*(2), 55–60.

Wan, T. H., Hsu, Y. S., Wong, J. Y., & Liu, S. H. (2017). Sustainable international tourist hotels: the role of the executive chef. *International Journal of Contemporary Hospitality Management*, *29*(7), 1873–1891. https://doi.org/10.1108/IJCHM-08-2015-0406

Yandri, V. (2012). PEMANFAATAN MINYAK JELANTAH SEBAGAI BIODIESEL UNTUK BAHAN BAKAR BUS KAMPUS UNAND DI PADANG. *Jurnal Aplikasi Ipteks Untuk Masyarakat*, *1*(2), 119–125.

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