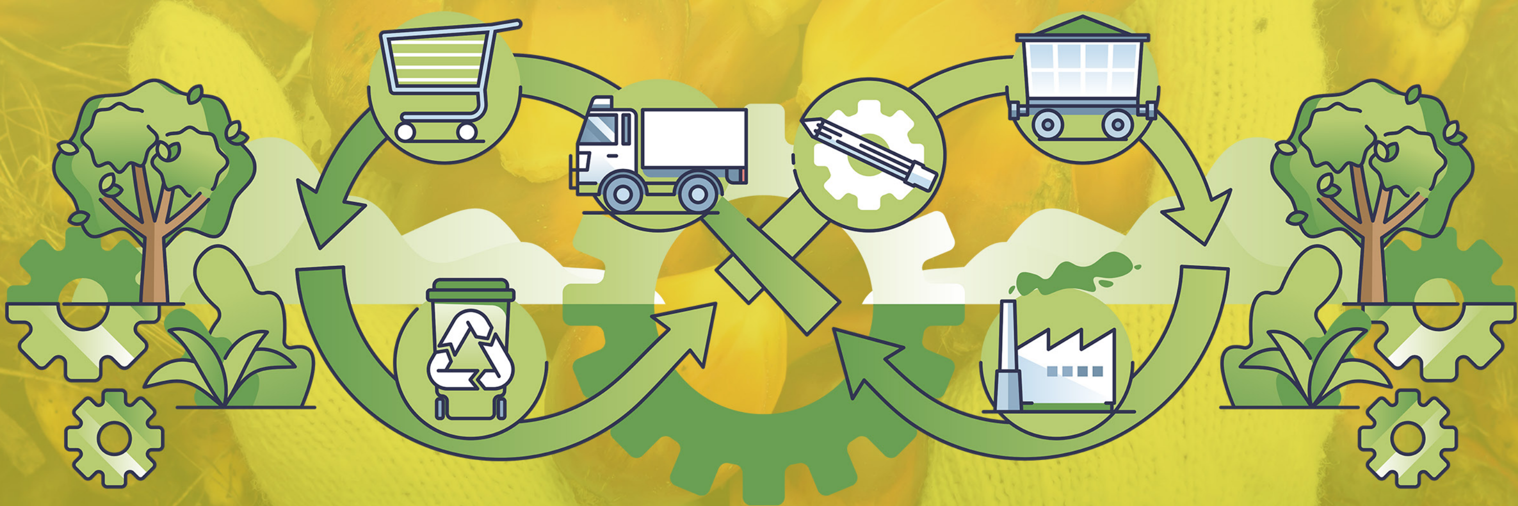
PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

Consolidated Policy Paper

Green and Inclusive Recovery through Circular Economy in Palm Oil Industry



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The report is published as part of the Partnership for Action on Green Economy (PAGE) – an initiative by the United Nations Environment Programme (UNEP), the International Labour Organization (ILO), the United Nations Development Programme (UNDP), the United Nations Industrial Development Organization (UNIDO) and the United Nations Institute for Training and Research (UNITAR).

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EXECUTIVE SUMMARY

Indonesia is endowed with abundant natural resources due to its tropical climate and archipelagic geography. However, the supply of crucial raw materials is limited. Finite supplies also mean that some countries depend on others for their raw materials. In addition, extracting and using raw materials have a significant impact on the environment, leading to increased energy consumption and CO2 emissions. In fact, one of the biggest challenges for Indonesia is to preserve its natural resources while maintaining stable economic growth.

Despite experiencing stable macroeconomic growth in the last decade, propelling it to become one of the largest economies in Southeast Asia, the country still faces major challenges in addressing certain issues. Continuing along Indonesia's current development path, marked by unsustainable exploitation of natural resources and investment in high carbon, inefficient energy, and transport systems, will restrict the Indonesia's growth, job creation, and its potential to eradicate poverty.

In October 2017, the Government of Indonesia declared its goal of integrating climate action into the country's development agenda. The **Low Carbon Development Initiative** (LCDI) was launched at Indonesia's Ministry of National Development Planning (BAPPENAS). It aims to explicitly incorporate greenhouse gas (GHG) emissions reduction targets into the policy planning exercise, along with other interventions for preserving and restoring natural resources.

With the COVID-19 pandemic revealing the vulnerability of global systems to protect the environment, health, and economy, the response to the devastating impacts of the pandemic becomes a major concern for governments, businesses, and civil society. The development of policies that maintain economic growth, alleviate poverty, and help meet sector-level development targets is highly relevant as new sources of growth and economic renewal are considered. As COVID-19 has also influenced the development policies of Indonesia, there is a need to develop and integrate low-carbon strategies into the COVID-19 recovery plans.

The ministry is currently spearheading post COVID-19 green economic recovery efforts with its approach: **Building Back Better with the Low Carbon Development Initiative** or **B3-Low Carbon**. The Government of Indonesia plans to incorporate the circular economy approach into its LCDI and green recovery strategy moving forward. There are already plans to integrate a circular economy indicators matrix into the next medium-term development planning (RPJMN) 2025-2029. The circular economy is also referenced in Indonesia's Vision for 2045 and the National Mid-term Development Plan (RPJMN) 2020-2024.

This work of consultancy is proposed to provide stakeholders with a set of policy recommendation regarding green and inclusive economic recovery through the circular economy in the food and beverages industry sectors. This aligns with the First Thematic Area proposed by PAGE Indonesia: Impact Assessment, support for greening economic stimulus packages, and mobilizing private finance for green recovery.

The proposed activities are kept intact:

1. Designing the final Work Plan for the consolidated policy paper, which includes analysis and strategic action plans for green recovery through the circular economy in the food and beverages industrial sectors, with a primary focus on the palm oil processing industry
2. Developing the final version of the consolidated policy paper (in both Bahasa Indonesia and English) that has been consulted with and agreed upon by UNDP Indonesia (UN-PAGE coordinator) and the Government of Indonesia (Bappenas).
3. Developing the final version of the policy brief (in both Bahasa Indonesia and English) that has been consulted with and agreed upon by UNDP Indonesia (UN-PAGE coordinator) and the Government of Indonesia (Bappenas).

Proposed Tools/Analyses (Ellen McArthur)

This methodology aims to explore and prioritise circular economy opportunities; quantify their impact; identify barriers preventing these opportunities; map and prioritise policy intervention to overcome these barriers; and engage relevant stakeholders. It is crucial to map and engage relevant stakeholders early in the process, aligning on the starting point, ambition, and focus. Once the focus sectors are selected, the sector-specific assessment can commence. This step can be conducted in parallel sector working groups, and heavily relying on the involvement of businesses to assess sector-specific circular economy opportunities. After the assessment of sector-specific circular economy opportunities, these can be aggregated, and the economy-wide implications analysed. This step is typically led by a core group of policy makers, policy, and economics experts, with the participation of multiple government agencies to analyse economy-wide implications.

Align on the starting point, ambition, and focus.

Relevant stakeholders need to be mapped and engaged early in the process. Based on an understanding of the national circularity and policy context (baseline circularity level and policy landscape), a realistic ambition level needs to be defined (set ambition level) and the sector scope needs to be determined (select focus sectors).

Table 1 Detail Align on Starting Point, Ambition, and Focus

Align on the starting point, ambition, and focus	Objective	End product
Baseline circularity level and policy landscape	Understand the country's starting point before deciding where to go.	Assess the country's level of circularity compared to other countries. Gain a broad understanding of the landscape of existing circular economy-related policies.
Set ambition level	Align stakeholders on the overall direction and focus for subsequent sector deep dives to work towards a common goal.	Clear, quantified ambition level.
Select focus sectors	Focus the assessment of sector opportunities on the most relevant parts of the economy.	A set of focus sectors is determined based on a prioritisation matrix that maps sectors according to their 'role in the national economy' and 'circularity potential'.

Assess sector opportunities

Once the focus sectors have been selected, the sector-specific assessment can begin. It involves mapping the most relevant circular economy opportunities in each focus sector and prioritising and detailing them. For the prioritised opportunities, a sector-specific economic impact needs to be assessed (quantify sector impact), barriers limiting their realisation identified (identify barriers), and policy options to overcome these barriers mapped (map sector-specific policy options).

Table 2 Detail Assess Sector Opportunities

Assess sector opportunities	Objective	End product
Map circular economy opportunities in each focus sector	Create an exhaustive overview of possible circular economy opportunities.	A structured mapping of potential circular economy opportunities for each focus sector, identified along the ReSOLVE framework.
Prioritise and detail circular economy opportunities	Prioritise and provide detailed information on opportunities in each focus sector based on their potential impact.	A set of one to three prioritised and detailed opportunities per sector.
Quantify sector impact	Understand the economic and resource impact of circular economy opportunities, either as input to an economy-wide assessment or as a standalone result.	Quantify the impact for each opportunity and circular economy scenario (where applicable).
Identify Barriers	Understand the barriers hindering the identified circular economy opportunities, to render policy options more targeted.	Importance and description of barriers for each opportunity, structured by 15 types of barriers across four categories (economic, market failures, regulatory failures, social factors).
Map sector-specific policy options	Present all relevant available policy options to address the barriers.	A list of policy options for each barrier related to each opportunity.

Analyse economy-wide implications

Once the sector-specific circular economy opportunities have been assessed, they can be consolidated and the national implications can be analysed. The sector-specific impact assessments could be combined into one an overarching whole-economy impact assessment to support the mandate for policy intervention (quantify economy-wide impact). Sector-specific policy options could be complemented by economy-wide policy options (map economy-wide policy options). The set of sector-specific and economy-wide policy options needs to be prioritised and assembled into coherent policy packages (prioritise, package, and sequence policy options).

Table 3 Detail Analyse Economy-Wide Implications

Analyse economy-wide implications	Objective	End product
Quantify economy-wide impact	Support the case for economy-wide and broad sectoral policy interventions.	Estimate the expected impact of circular economy opportunities on national macroeconomic indicators such as GDP, employment, net exports, and carbon emissions.
Map economy-wide policy options	Complement sector-specific policy options identified in the mapping of sector-specific policy options with economy-wide policy options to enable a broad transition to the circular economy.	List of economy-wide policy options.
Prioritise, package, and sequence policy options	Complement sector-specific policy options identified in the mapping of sector-specific policy options with economy-wide policy options to enable a broad transition to the circular economy.	List of economy-wide policy options.

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INTRODUCTION & PRELIMINARY STUDY

1.1 Background

The challenges of climate change, coupled with issues on nature and pollution, constitute what is often termed the triple planetary crisis. This multifaceted predicament encompasses adverse effects on the habitability of Earth, the alarming loss of biodiversity, and the jeopardizing of human well-being on a global scale (Andersen, 2020). Indonesia, as the world's largest archipelagic state, faces heightened vulnerability due to its tropical climate, placing it in the upper echelon of nations at significant risk of climate-related impacts (World Bank, 2021; The World Bank Group & Asian Development Bank, 2021). The country grapples with a diverse range of challenges, from extensive exposure to flooding and extreme heat to projections of increased exposure to river floods, potentially affecting 1.4 million individuals by 2035-2044 (The World Bank Group & Asian Development Bank, 2021). Moreover, Indonesia's agricultural sector faces threats from rising temperatures, posing a significant risk to the nation's food security (The World Bank Group & Asian Development Bank, 2021). Notably, the financial toll of these challenges could amount to 2.5-7% of Indonesia's GDP, disproportionately affecting the most economically vulnerable segments of society (World Bank, 2021).

To prevent this from happening, Indonesia is committed to reducing 31.89% (with self-effort) or 43.20% (with international support) of its emissions by 2030 and becoming net zero by 2060 (Republic of Indonesia, 2022). This commitment is embedded within Indonesia's strategic plan for sustainable development, specifically outlined in its Long-term Development Plan spanning 2025-2045. The fifth pivotal target in this plan specifically aims to curtail greenhouse gas emission intensity, steering the nation towards achieving net-zero emissions. This commitment involves a comprehensive mission focused on implementing a green economy paradigm that encompasses several key strategies: energy transition, low-carbon development implementation, circular economy implementation, and green financing mechanisms development. In this policy report, we will focus on reducing greenhouse gas emissions through a circular economy implementation.

As of 2023, the global circularity rate has decreased to 7.6% from 8.6% in 2020 (Kementerian PPN/Bappenas, 2023). This declining trend suggests a worrisome reduction in sustainable resource utilization and the promotion of circular economic practices, which are crucial for mitigating environmental impacts and enhancing long-term resilience against such crises. Therefore, this report aims to increase circularity through circular economy intervention in Indonesia. A circular economy system refers to efforts to maintain the value of products, materials, and resources in the economy as long as possible, while still generating economic growth (Bappenas, 2022).

Indonesia has identified five prioritized sectors for circular economy implementation based on each sector's contribution to the overall GDP and employment rate. These five sectors alone contributed to one-third of Indonesia's overall GDP and employed more than 43 million people in 2019 (Bappenas, 2022). The sectors are (i) food & beverages (ii) textile (iii) construction (iv) wholesale & retail trade, and (v) electrical and electronic equipment. The food and beverage sector accounted for 9.3 percent of the total GDP in 2019 and was the largest sub-sector of the manufacturing sector, which itself was the largest industry sector in Indonesia (PT Kreasi Rekayasa Indonesia). Thus, the need for a circular economic transformation in this sector is crucial.

The Government of Indonesia (GoI) has aligned its circular economy strategy with a focus on the 5Rs: Reduce, Reuse, Recycle, Refurbish, and Renew. The government's qualitative analysis of the food & beverages (F&B) industry highlights the potential of the "Reduce" and "Recycle" approaches for circularity (PT Kreasi Rekayasa Indonesia). Considering the diverse characteristics within the F&B sector, a quick assessment is essential to pinpoint the specific subsector that notably contributes to Indonesia's low carbon development (LCDI) and holds the greatest potential for circular economy (CE) practices.

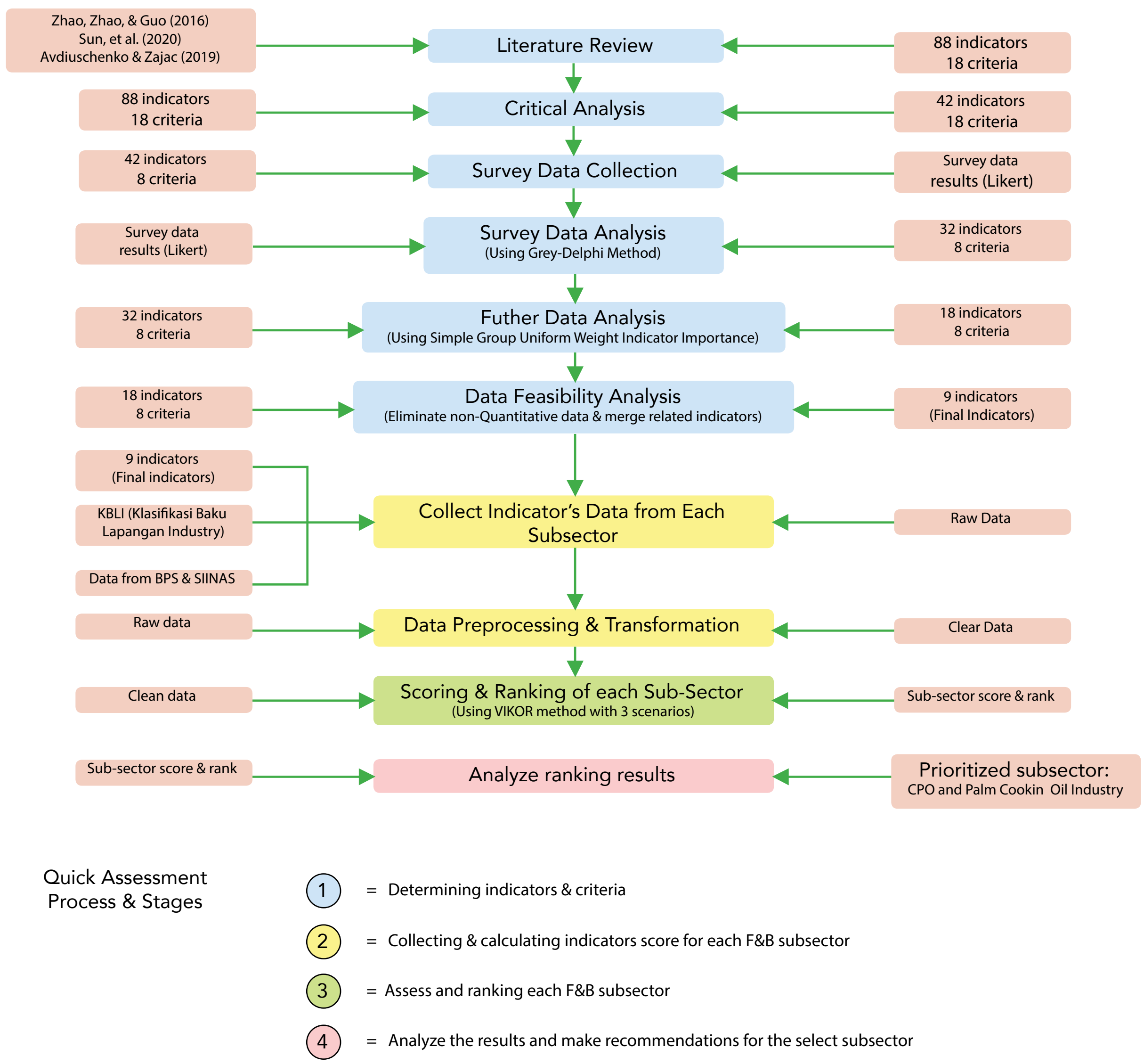


Figure I-1 Quick assessment outline

The quick assessment begins by determining which indicators need consideration before collecting and calculating the impact of each F&B subsector. This selection of indicators is derived from an extensive literature review of three primary papers and the collection of survey data from relevant industry professionals. Through meticulous data analysis, a set of nine indicators has emerged as the foundational metrics for gathering and computing data from each subsector. Table I1 encapsulates the ultimate indicator and the data, acting as a proxy to quantify the impact of each indicator. Prioritization will rely primarily on data sourced from BPS (Badan Pusat Statistik or Statistics Indonesia) and SIINAS (Sistem Informasi Industri Nasional or Indonesian Ministry of Industry's Database). However, before these datasets can be utilized to assess the impact of each subsector, a crucial step involves cleaning and pre-processing the data to ensure accuracy and reliability in subsequent analyses.

The approach chosen to assess the impact of each subsector is the VIKOR method, a multicriteria optimization technique designed to navigate trade-offs between conflicting criteria. Three major scenarios in this study are constructed based on the variety of methods used, imputation method, and observed sector. Notably, upon conducting VIKOR calculations for each scenario, the palm oil processing industry consistently emerges at the forefront of the rankings. A detailed analysis across indicators further underscores this subsector's notably superior values compared to others. Hence, based on this comprehensive evaluation, **the palm oil industry stands out as the selected subsector for this study**. The outline and overview of how the quick assessment was conducted can be seen on Figure I1.

Table I1 Final Indicators for VIKOR analysis

No.	Indicators	Data (Proxy)
1.	Economic annual average growth rate of sub-sector added value	GDP (value-added)
2.	Potential to increase employment	Number of employees
3.	Industrial water recycling rate	Water consumption
4.	Energy recycling rate	Energy consumption
5.	Potential power consumption reduction rate per unit sub-sector output	Power consumption
6.	Waste treatment facilities	Volume
7.	Potential toxic and hazardous waste reduction	Toxic emission (B3)
8.	Potential carbon dioxide emission reduction	CO2 emission
9.	Potential other GHG emission reduction	Other GHG emission

The synthesized report will consolidate insights from various sources, including UNIDO's findings on resource efficiency, ILO's analysis of labor potential within the palm oil industry, UNEP's examination of fiscal and non-fiscal incentives, and the Life Cycle Assessment with Waste & CO2 Reduction (LCA-WCR) conducted by academic and research agencies. This consolidated report aims to draw upon the comprehensive perspectives offered by these diverse sources, facilitating a holistic understanding of the palm oil industry's dynamics, resource utilization, labor prospects, and the efficacy of incentives. The goal is to pave the way for informed decision-making and strategic planning within the sector.

1.1 Policy Landscape Study

To support a more sustainable development that balances economic, social, and environmental aspects, the Indonesian government has adopted several regulations as shown in Table I2. The findings from the Center of Reform on Economics (Enabling Policy Environment to Encourage Private Sector Investment for Circular Economy Practices in Indonesia's Agriculture-Based Food and Beverage Sector, 2023) indicate that circular economy regulations in Indonesia are limited, with the majority focusing on emissions reduction. Some of these regulations are still in the planning stage, and their effectiveness is yet to be identified.

Table I2 Circular Economy Regulation in the Indonesian Manufacturing Industry

[1] (Center of Reform on Economics, 2023)

[2] (ILO, 2023)

No	Regulation	Description	Note
1	Law (UU) No. 7/2021 on Tax Regulation Harmonization1	The rules, among other things, regulate carbon tax imposition on carbon emissions that harm the environment at a rate of Rp30/kg CO2 (this tariff is relatively very low compared to developed countries, such as the European Union, which reaches US$50 [ETS]).	The regulation becomes distinctive for industries that produce carbon emissions and indirectly promote the circular economy concept.
2	Law (UU) No. 18 of 2008 on Waste Management1	The rules, among others, explain the provision of incentives by the government for everyone who reduces waste and disincentives for those who do not.	The Ministry of Finance plans to provide fiscal incentives for waste management. However, according to the Indonesian Plastic Recycling Association (Asosiasi Daur Ulang Plastik Indonesia/ADUPI), they have not received tax incentives since the rule's promulgation.
3	Presidential Regulation No. 98/2021 on the implementation of the Carbon Pricing (NEK) 1	These rules, among other things, include appreciation and awards for businesses and/or activities that go beyond their obligations to reduce GHG emissions through their efforts.	The government plans to provide incentives for industries that implement sustainability principles.
4	Ministry of Industry Regulation Number 47/2020 on Green Industry Standard for Mineral Water Industry1	The regulation, among other things, mandates bottled drinking water (Air Minum Dalam Kemasan) suppliers to use at least one percent recycled plastic in packaging and to have a licensed Wastewater Treatment Plant (WWTP) managed by third parties.	According to the government, the provision has undergone discussion and approval of industry players.
5	Ministry of Environment and Forestry Regulation Number 75/2019 on Roadmap of Waste Reduction by Producer1	This rule, among others, obligates the manufacturing industry to use recyclable packaging and limit the size of food products. For example, carton packaging for liquid products must be at least 250 mililiters; and/or powdered products must have a minimum weight of 200 grams.	The stages of waste reduction, according to the planning documents, will be implemented in 2023.
6	Presidential Regulation No. 44/2020 on the Indonesian Sustainable Ministry of Environment and Forestry Regulation Number 38/2020 Palm Oil Plantation Certification System2	This regulation obliges all stakeholders, including smallholders, to acquire ISPO certification within five years.	In 2017, RSPO and ISPO conducted joint research on the similarities and concluded that almost 75 percent of the criteria are similar, with the main differences arise concerning to the High Conservation Value (HCV) principle, Free Prior and Informed Consent (FPIC), and New Planting Procedures (FCP).

1.3 Indonesia's Circularity Target

Within Indonesia's policy context, the circular economy concept has been adopted in the development and climate mitigation policies. These include the following five Indonesia's circularity ambitions: Indonesia Vision 2045, The Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050, Middle Term National Development Plan (RPJMN) for 2020-2024, Palm Roadmap for 2019-2045, and National Action Plan on Sustainable Palm Oil (NAP SPO) for 2019-2024 (ILO, 2023). In addition, Lugito & Saputera (Part 3 | Waste & CO2 Reduction Life Cycle Assessment) mention the Indonesian government's commitment to achieving Net-Zero Emission by 2060.

1. Net-Zero Emission 2060
   Indonesia has submitted its enhanced NDC (Nationally Determined Contribution) to the UNFCC secretariat by 23 September 2022. The enhanced NDC states that Indonesia aims to reduce emission by 31.89% unconditionally and 43.20% conditionally with a vision to achieve net-zero emission by 2060 or sooner (Republic of Indonesia, 2022).

2. Indonesia Vision 2045
   In achieving the Vision of Indonesia, the Indonesia Vision 2045 is designed with four pillars: (1) Human Development and Proficiency in Science and Technology, (2) Sustainable Economic Development, (3) Development Equality, and (4) Reinforcing National Resilience and Governance (Kementerian PPN/ Bappenas, 2019).

3. The Long-Term Strategy for Low Carbon and Climate Resilience 2050
   The LTS-LCCR 2050 sets the goal of adaptation pathways to reduce the impact of climate change on national GDP loss by 3,45% in 2050, through increasing resilience in four basic necessities (food, water, energy, and environmental health), with three target areas of resilience (economy, social and livelihood, ecosystem and landscape (Ministry of Environment and Forestry, 2021).

4. Middle Term National Development Plan for 2020-2024
   The RPJMN 2020-2024 establishes four main streams to shape innovative and adaptive development, serving as drivers for progress towards a prosperous and equitable society, namely: sustainable development goals, gender, socio-cultural capital, and digital transformation (Presiden Republik Indonesia, 2020).

5. Long Term National Development Plan for 2025-2045
   Indonesia has established the strategy to reduce 93.5% of GHG emissions by 2045 and achieve net zero by 2060 in its Long Term National Development Plan (RPJPN 2025-2045). To achieve this target, Indonesia has incorporated Green initiatives in many operational activities to ensure alignment across sectors. This Long-Term National Development Plan (RPJPN 2025-2045) is pivotal in ensuring that Indonesia can achieve a good balance between economic growth and circularity.

6. Palm Roadmap for 2019-2045
   The Government of Indonesia developed the Palm Roadmap 2019-2045 with the vision in developing sustainable palm oil industry as one economic development building block (Kementerian PPN/Bappenas, 2021). The roadmap initiates three areas of strategy: improving productivity, down-streaming, and improving ecosystem, governance, and capacity building. The roadmap also aims to mainstream circular economy in the palm industry as a foundation for bio-economy development.

7. National Action Plan on Sustainable Palm Oil for 2019-2024
   The Government of Indonesia developed NAP SPO for 2019-2024, stipulated under Presidential Decree No. 6 of 2019, to strengthen the sustainability of the palm oil industry. The NAP SPO is aimed at promoting the capability and capacity of palm growers, acceleration of land legal status, promoting the use of palm for renewables, improving sustainable palm plantation diplomacy, and promoting the acceleration of sustainable palm oil. The NAP SPO focuses on five areas: (1) improving data collection,

coordination, and infrastructure, (2) capacity development for palm growers, (3) improving palm plantation governance and dispute settlement, (4) acceleration of ISPO certification and market access, as well as (5) environmental management and monitoring.

1.4 Stakeholders Analysis

To ensure the successful implementation of our proposed recommendations at both national and local levels, strategic engagement with various stakeholders is crucial. These stakeholders will be categorized into distinct groups based on the ABCG (Academic, Business, Community, & Government) classification framework. This categorization allows for a comprehensive understanding of their roles and involvement in the process. This structured approach aims to foster collaboration among diverse stakeholders, leveraging their expertise and perspectives to effectively execute the proposed recommendations. The list of stakeholders involved in this policy paper can be seen in Table I3. A detailed explanation of each stakeholder's responsibilities and contributions will be provided in the subsequent section.

Table I3 Stakeholder Analysis - ABCG Classification

Academic (A)
Research & Academic Institutions
Business (B)
• Manufacturing Companies • Corporate Plantation (Wilmar Group, PTPN III, PTPN V, PT. SMART) • Smallholder Plantation
Community (C)
• Association of Indonesian Palm Oil Entrepreneurs (Gabungan Pengusaha Kelapa Sawit Indonesia – GAPKI) • Indonesia Palm Oil Smallholders Association (Asosiasi Petani Kelapa Sawit Indonesia – APKASINDO) • GIMNI (Gabungan Industri Minyak Nabati Indonesia)
Government (G)
Nation-wide • Indonesian National Police • Indonesian National Army **Ministry** • Ministry of Agriculture (Kementerian Pertanian) • Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan - KLHK) • Ministry of Small and Medium Enterprises and Cooperatives (Kementerian Koperasi dan Usaha Kecil Menengah – Kemenkop UKM) • Minitry of National Development Planning (Badan Perencanaan dan Pembangunan Nasional - Bappenas) • Ministry of State-Owned Enterprises (Kementerian BUMN) • Ministry of Education, Research, and Techology (Kementerian Pendidikan, Kebudayaa, Riset, dan Teknologi – Kemendikbudristek) • Ministry of Trade (Kemeterian Perdagangan – Kemendag) • Ministry of Industry (Kementerian Perindustrian – Kemenperin) • Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumber Daya Mineral – Kementerian ESDM) • Ministry of Public Works and Housing (Kementerian Pekerjaan Umum dan Perumahan Rakyat – Kementerian PUPR) • Ministry of Finance (Kementerian Keuangan – Kemenkeu)

Independent Institution
- Financial Services Authority (Otoritas Jasa Keuangan – OJK)
- BPDKS (Badan Pengelola Dana Perkebunan Kelapa Sawit)
- Investment Coordinating Board (Badan Koordinasi Penanaman Modal - BPKM)
- National Research and Innovation Agency (Badan Riset dan Inovasi Nasional - BRIN)

State-Owned Enterprise
- Perusahaan Listrik Negara (PLN)

Provincial and District
- Provincial Government
- District/Local Government

CHAPTER 2

PALM OIL INDUSTRY ASSESMENT

2.1 Opportunities & Barriers in Indonesia's Palm Oil Industry

As one of the world's major agricultural nations, the agriculture, forestry, and fisheries (AFOLU) sector play a vital role in Indonesia's economy. Amongst these, the plantation subsector is the most significant contributor, providing 3.9% of the total GDP, or 30% of the AFOLU sector (Center of Reform on Economics, 2023). **Within the plantation sector, palm oil makes the biggest contribution (35%) and has high potential for growth.** This is evident in the nearly doubled palm oil production from 2020 to 2021, totaling 45.1 million tons (Directorate of Food Crops, Horticulture, and Estate Crop Statistics, 2021). The distribution and the percentage of palm oil coverage can be seen in Figure II1.

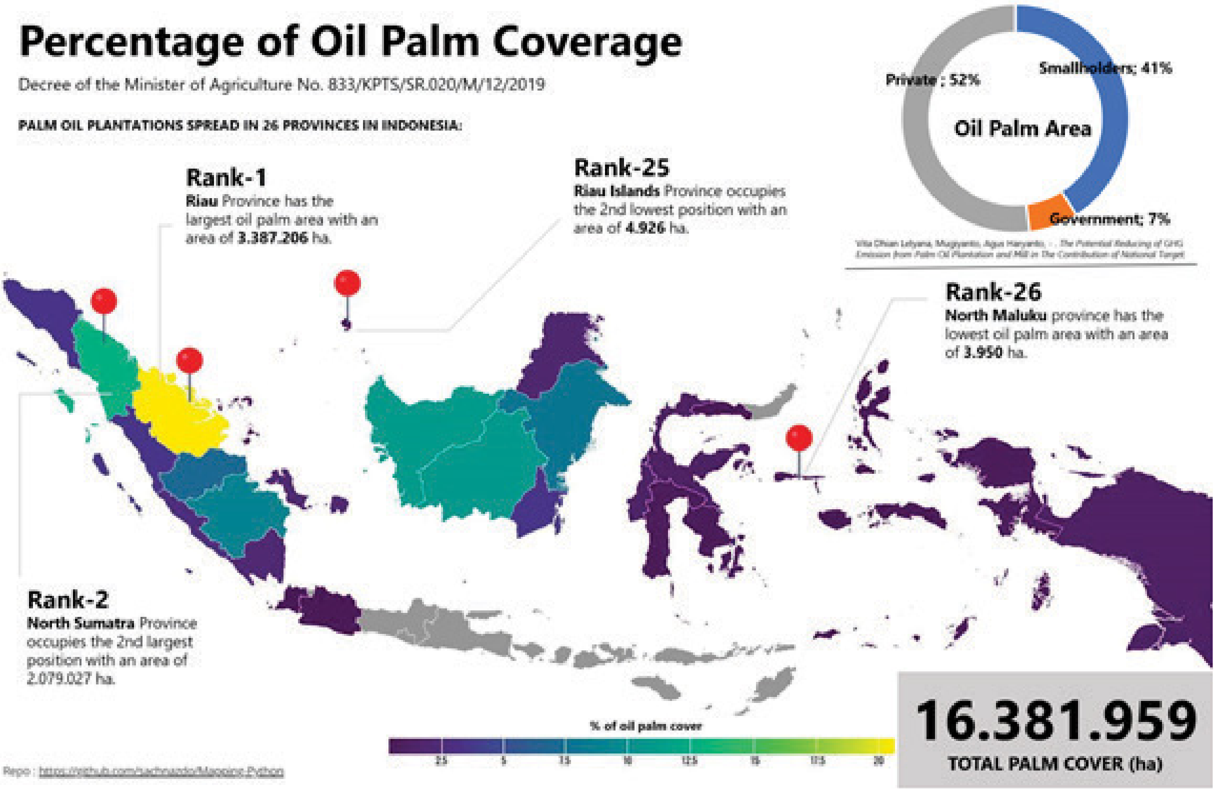


Figure II1 Distribution of palm oil plantation and production in Indonesia

As technology for downstream CPO product advances, the export share of palm oil derivatives has also expanded from 54 varieties in 2011 to 168 varieties in 2021, resulting in a total export value of US$26.7 billion. This number represents 17.6% contribution to total non-oil and gas exports in 2021.

Given that Indonesia holds 10% of the total global land bank for vegetable oil, **Indonesia has the potential** to produce 40% of the world's total vegetable oil needs, **control 55% of the global palm oil market share, and become the largest palm-oil producing country** (Center of Reform on Economics, 2023). On the other hand, the development of palm oil plantation has been closely related to the issues of deforestation and the destruction of carbon-rich peatland (Lugito & Saputera). The international community has flagged the expansion of palm oil plantations as a major contributor to carbon emissions. The EU, via its Renewable Energy Directive (RED II) policy, has labeled biodiesel sourced from palm oil as an environmentally harmful energy option, classifying it as high-risk and unsustainable. In Indonesia, research shows that palm oil plantations are responsible for approximately 20-25 tons of CO2-eq emissions per hectare per year or equal to 13.8% of national emissions (BPDP, 2020; Lelyana, Mugiyanto, & Haryanto). With such big contribution in

GHG emission and rising demand for sustainable palm oil that meets RSPO criterion, **the palm oil industry in Indonesia is exposed to high transition risks** (Lugito & Saputera).

To address transition risks within the palm oil industry and elevate Indonesia's global competitiveness while capitalizing on its potential market share, the country launched the Indonesian Sustainable Palm Oil (ISPO) certification in 2011. With the enactment of Indonesia's Presidential Decree No. 44/2020, all stakeholders, including smallholders, are mandated to acquire an ISPO certificate within a five-year period. As of June 2020, 621 ISPO certificates had been issued, encompassing 38.03% of Indonesia's palm oil plantations (Lugito & Saputera).

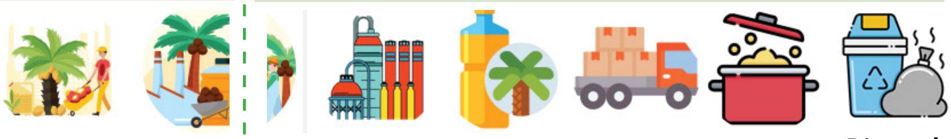
2.2 Palm Oil Industry Value Chain

The Center of Reform on Economics (Enabling Policy Environment to Encourage Private Sector Investment for Circular Economy Practices in Indonesia's Agriculture-Based Food and Beverage Sector, 2023), International Labour Organization (Circular Economy in the Food & Beverage Industry for Green Recovery - PAGE Indonesia In-depth Assessment on Green Jobs and Skill Needs, 2023), Lugito & Saputera (Part 3 | Waste & CO2 Reduction Life Cycle Assessment), and Sambodo, et al. (Identifying Circular Economy Opportuinties In the Palm Oil Sector in Indonesia, 2023) classified the palm oil value chain differently in their studies.

Figure II2 shows the classification of palm oil value chain from each study. Plantation, mill, refinery, and packaging value chain are mentioned in all four studies. Disposal value chain is mentioned in three studies. On the other hand, use and distribution value chain are mentioned in two studies. However, in general, the palm oil value chain is typically split into upstream and downstream segments. In this paper, the palm oil is classified into five value chains: plantation and mills constructing upstream segments while refinery, packaging and distribution, as well as post consumption (use and disposal) constructing downstream segments. Further details of the supply chain process in the palm oil value chain can be seen on Figure II3.

Consolidated Policy Paper on Palm Oil Circulatity | Bappenas

The palm oil value chain



	Upstream		Downstream			Post consumption	
	Plantation	Milling	Refinery	Packaging	Distribution	Use	Disposal
CORE	✓	✓	✓	✓			✓
ILO	✓	✓	✓	✓		✓	✓
Lugito & Saputera	✓	✓	✓	✓	✓	✓	✓
Sambodo	✓	✓	✓	✓	✓		
Consolidated Police Paper	✓	✓	✓	✓	✓	✓	✓

Figure II2 The Palm Oil Value Chain

The palm oil supply chain commences by preparing and assigning land for palm oil plantations. In cases where suitable land is unavailable, there is a tendency to forcibly convert existing forests or peatlands into suitable landscapes for palm oil cultivation, often categorized as Land Use, Land-Use Change, and Forestry (LULUC) activities. However, due to the complexity and uncertainty in calculating emissions from land transformation, this report will specifically focus on calculations by ignoring LULUC activities (without LULUC).

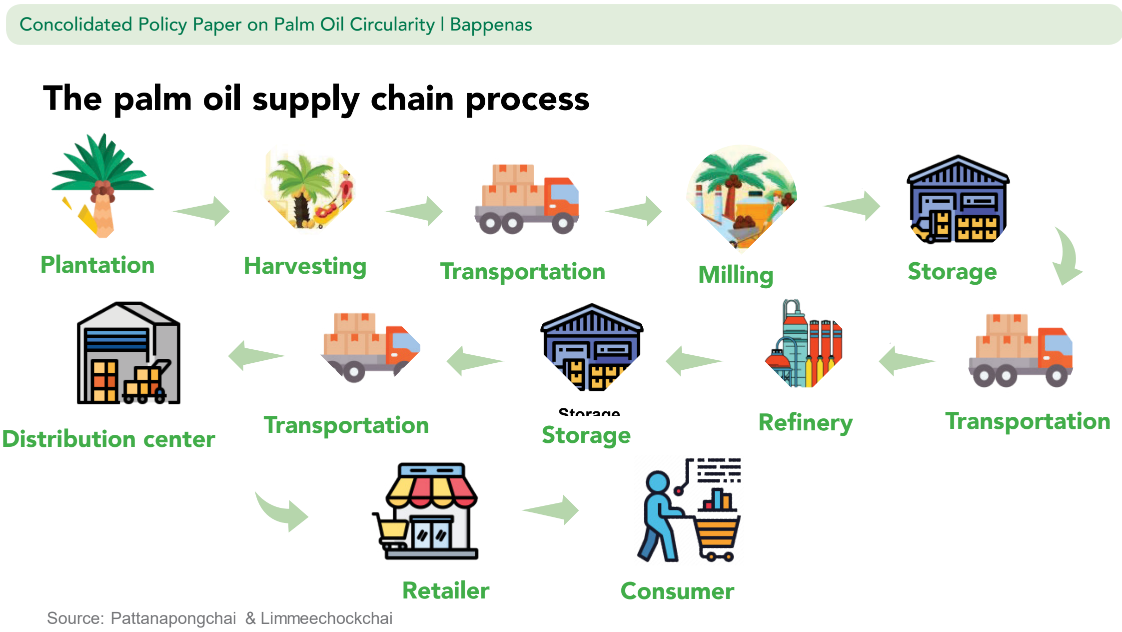


Figure II3 Overall palm oil supply chain process

Once the land is prepared, palm oil is cultivated, and Fresh Fruit Bunches (FFBs) are harvested from the trees. These FFBs serve as inputs for the mill value chain. Milling facilities process the FFBs into Crude Palm Oil (CPO), constituting the upstream output. Moving downstream, CPO undergoes transportation to refinery facilities to enhance its quality, appearance, and stability. In general, CPO can be refined into three groups: the oleo food complex, oleochemical complex, and biofuel complex (Center of Reform on Economics, 2023). The oleo food complex consists of industries that transform refinery industry products into intermediate oleo food or oleo food finished goods (Center of Reform on Economics, 2023). Oleochemicals are a popular ingredient in medical, toiletry, and cosmetics products (Center of Reform on Economics, 2023). In addition, biofuel products are currently combined with fossil fuels at concentrations of up to 30 percent (Center of Reform on Economics, 2023). **Figure II4** depicts the palm oil derivatives sector in Indonesia.

Figure II4 The Palm Oil Derivatives Sector in Indonesia (PASPI, 2017)

To facilitate smooth distribution, the refined palm oil is packaged based on specific size requirements and distributed either domestically or exported globally. During disposal, refined palm cooking oil can pose significant environmental challenges. Therefore, efforts to utilize waste from refined palm oil are needed to address these concerns. The full end-to-end diagram of the palm oil supply chain can be seen in Figure II5.

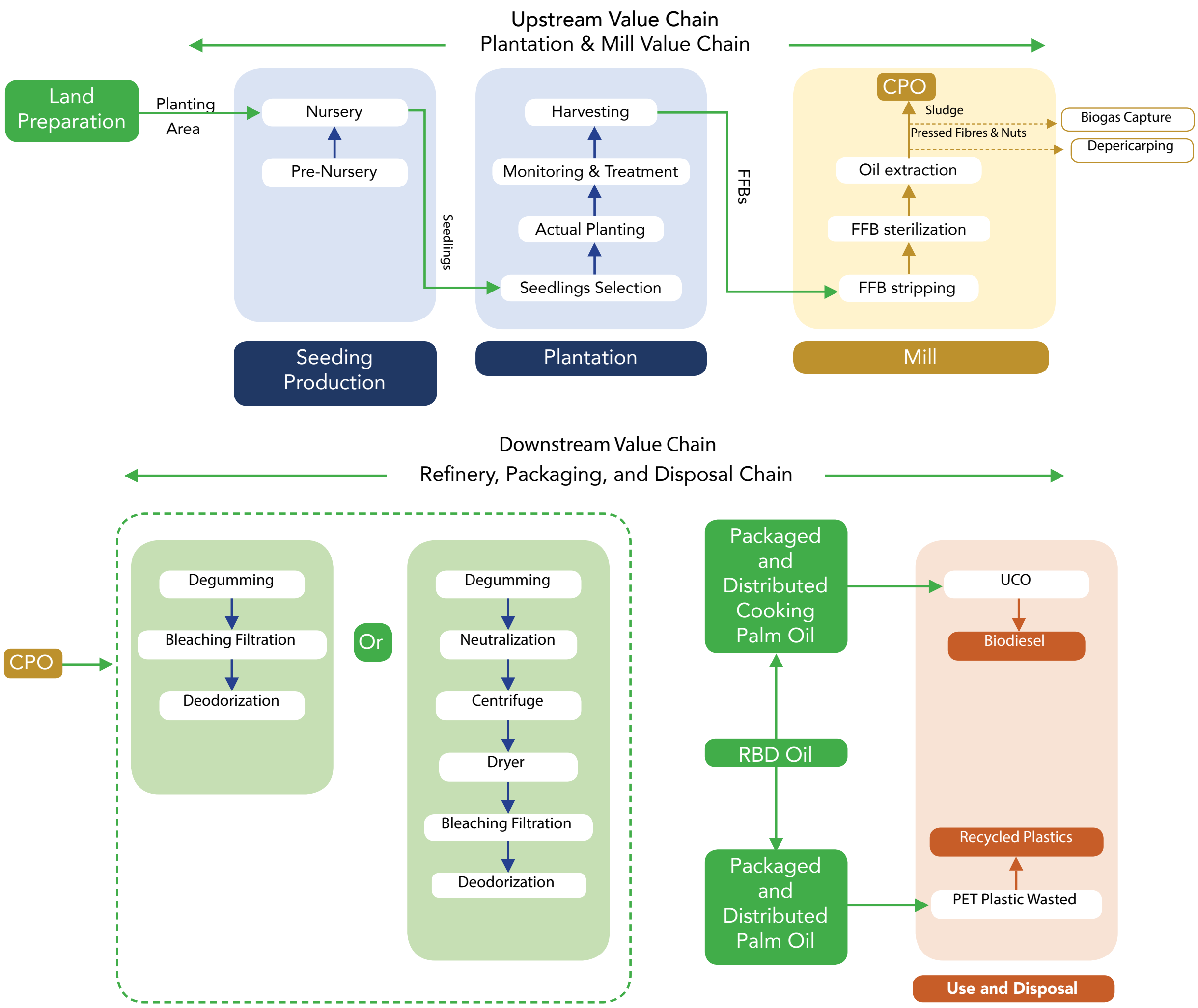


Figure II5 The Palm Oil Supply Chain Process

2.3 Critical Analysis of Palm Oil Industry Value Chain

Further exploration of the identified value chain is essential to formulate policy recommendations aimed at advancing the circularity of the palm oil industry. This analysis will begin by meticulously dissecting the industrial process to understand the resource needs at every stage of the value chain. Emphasis will be placed on identifying prospects for waste reduction and CO2 emissions mitigation, thereby amplifying resource efficiency and nurturing a circular, sustainable supply chain. Moreover, the analysis will delve into the potential for generating environmentally friendly production opportunities and delineate the fiscal and non-fiscal strategies required to bolster Indonesia's palm oil industry towards circularity.

1.3.1 Plantation & Mill Value Chain

Plantation & Mill value chain encompasses the foundational stages of production, starting from cultivating palm oil trees to the extraction of crude palm oil (CPO). The plantation phase involves selecting suitable land for cultivating and nurturing palm oil trees, implementing sustainable agricultural practices, and harvesting fresh fruit bunches (FFBs) when the fruits reach maturity. Meanwhile, the milling phase consists of transporting the FFBs to palm oil mills, where they undergo processing to extract crude palm oil (CPO).

The efficiency and sustainability of the upstream process significantly impacts the quality of palm oil, environmental conservation, and social aspects within the industry. Sustainable practices in land use, biodiversity conservation, labor rights, and waste management play a crucial role in ensuring a responsible and environmentally friendly palm oil production process at the upstream level—where the most significant environmental and social impacts of palm oil production occur.

Process in Plantation Value Chain

The plantation value chain consists of two main phase that is the production of palm oil seedlings (nursery stage) and the palm oil cultivation in the field stage (Silalertruksa, et al., 2016). The success of a palm oil plantation is significantly influenced by the palm oil seedling or seed development process. In the field, the process typically involves meticulous selection of healthy seedlings for planting, actual planting, on-going care, and eventual harvesting (Silalertruksa, et al., 2016).

There are two types of trees that are commonly cultivated by farmers: *Elaeis Guineensis Jacq*. and *Elaeis Oleifera* (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). It requires 1045 m2 of land and 397 kg of FFBs to produce 100 kg of CPO (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). These trees are typically maintained at a density of 131 – 137 trees per hectare and start bearing fruit bunches between 2.5 to 3 years after being planted in the field (Silalertruksa, et al., 2016). The first significant harvest occurs around five years into the growth cycle, and the trees typically last around 25 years before needing replanting (Silalertruksa, et al., 2016). The water requirement for producing FFBs averages to 1063 m3/t (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The application of urea fertilizer to palm oil plants ranges from 19.11 – 22.17 kg of urea/ha fertilizer (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

Harvesting frequency usually occurs every 10-15 days or 2-3 times monthly (Silalertruksa, et al., 2016). While most harvesting activities are manual, some fossil energy-powered machinery, farm equipment, and trucks are used for transporting FFBs.

The full diagram of the palm oil plantation value chain can be seen in Figure II6. Further analysis on emissions and waste reduction potentials from the palm oil plantation's value chain will be explained in the subsequent section.

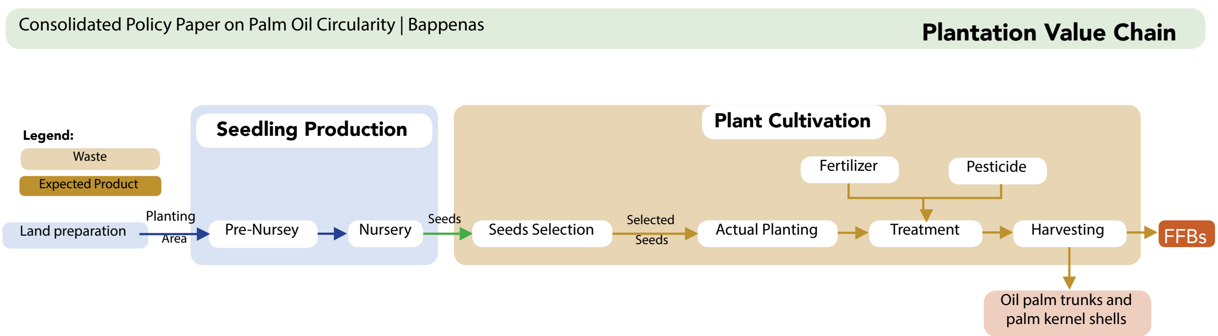


Figure II6 Process in plantation value chain

Source: (Silalertruksa, et al., 2016; Lugito & Saputera)

Mill Value Chain

The Fresh Fruit Bunches (FFBs) that come from the plantation are transported to the milling location for further processing into CPO. The mill value chain process can be classified into five steps: sterilization, stripping, pressing, extraction, and CPO drying & purification (Lugito & Saputera). Initially, the FFBs are fed into a sterilizer and then sent to a threshing drum where the fruits are stripped and seperated from the bunches (Kamarden, et al., 2018). The fruits are subsequently pressed in a screw presser to extract pressed oil from the fruit (Kamarden, et al., 2018). The pressed oil is then pumped into the clarification tank for oil separation (Kamarden, et al., 2018). The separated oil, containing fibrous solid undergoes further seperation in a high-speed centrifuge before being sent to the vacuum dryer (Kamarden, et al., 2018). The desired products from the milling process are crude palm oil (CPO) and kernel nuts; while the waste consists of palm oil mill effluent (POME), empty fruit bunch (EFB) and fruit fiber. Further analysis on emissions and waste reduction potentials from mill value chain will be explained in the subsequent section. The full diagram of the mill value chain can be seen in Figure II7.

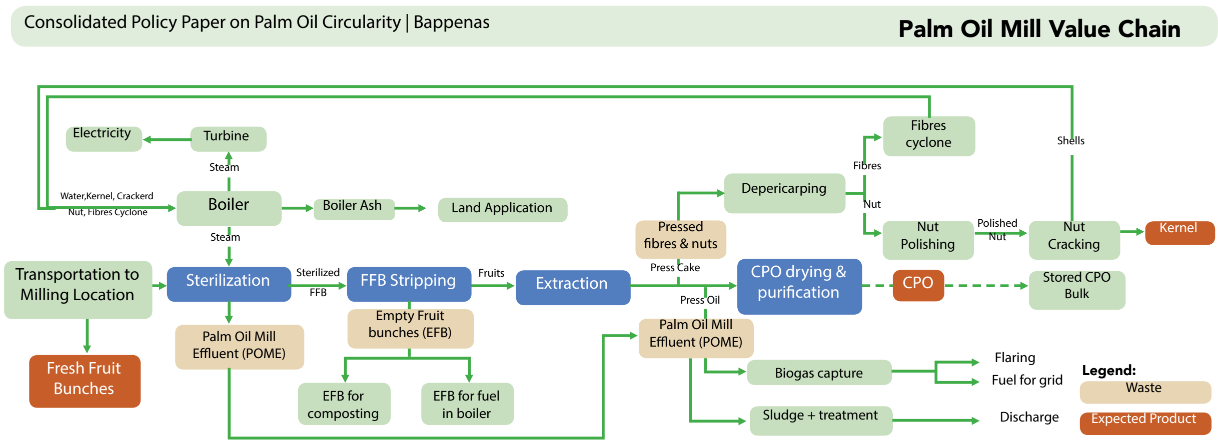


Figure II7 Process in palm oil mill value chain

Source: (Lugito & Saputera)

2.3.1.1 Waste and CO2 Reduction

This section covers a detailed analysis of waste & CO_2 emission in the upstream value chain. According to the Agri footprint data inventory, the production of 100 kg CPO requires 23.6MJ energy, generates 171 kg solid waste and produces 403 kg of wastewater (Lugito & Saputera). These values will serve as the baseline or calculating the lifecycle analysis and global warming potential (GWP) of the plantation & mill value chain.

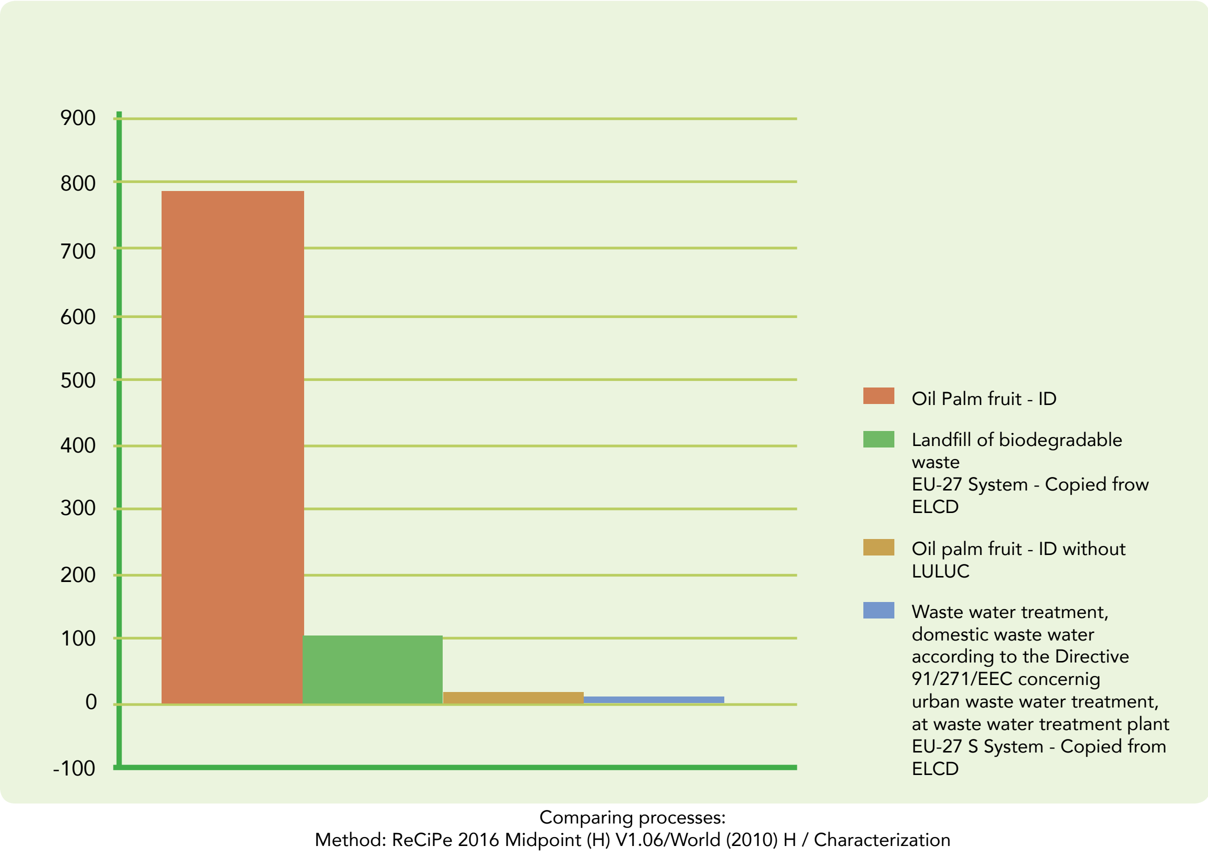


Figure II8 Lifecycle impact assessment of Plantation and Mill on Global Warming

Source: (Lugito & Saputera)

The growing demand for palm oil has led to the rapid expansion of palm oil plantation particularly in Indonesia (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). As plantations expand, more land is being converted for palm oil cultivation as part of the land preparation process (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Assuming that a palm oil plantation yields 3.8 ton of FFB/ha-year, land transformation alone is responsible for 770 kg CO2-eq/100 kg produced CPO or 96.4%wt of the total emission from plantation with LULUC value chain (Lugito & Saputera).

Figure II8 demonstrates that the presence of LULUC activities notably influences the total CO2-eq emissions in the palm oil value chain, creating a substantial gap between it and the second-ranking contributor. However, land transformations take place only once at the beginning of plantation, and the land could be utilized for a long time afterward; consideration of LULUC may not be relevant for this study.

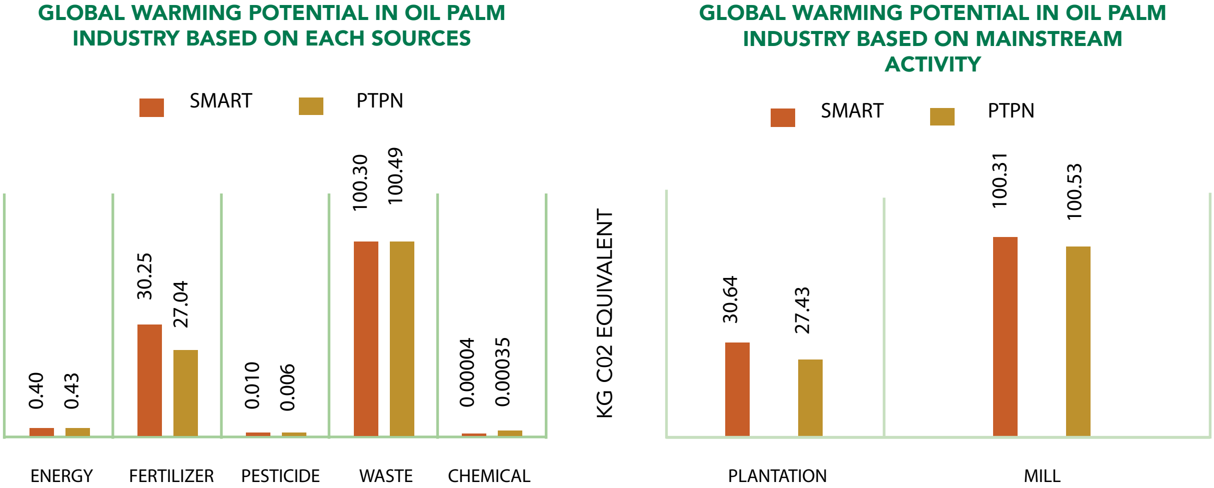


Figure II9 Global warming potential (GWP) without LULUC comparison of PT. SMART and PTPN V based on source and mainstream activities

Source: (Lugito & Saputera)

Without LULUC, the accumulation of emission from Mill is significantly higher than plantation. However, a detailed breakdown reveals that within each source classification, the primary contributors to greenhouse gas (GHG) emissions in the upstream segment are fertilizer from plantation value chain and waste from mill value chain. A thorough calculation and breakdown of the emission can be seen in Table II1. Without LULUC, the total were reduced to 28.7 -eq/100 kg CPO from plantation value chain and 207 -eq/100 kg CPO from mill value chain. In the plantation value chain, emissions from fertilizer take the lead, followed by energy (3.77%) and infrastructure (3.56%). Conversely, in the mill value chain, waste and wastewater emissions take precedence, followed by energy (0.93%).

Given its significant contribution to greenhouse gas emissions, maximizing waste utilization is crucial to fostering circularity within the palm oil value chain and mitigating its adverse effects. The illustration to visualize waste reduction opportunities in the mills & plantation value chain can be seen in Figure II10. Mill waste contains minerals that hold valuable potential as nutrients. These minerals can enrich soil quality, improving the C/N ratio and thereby lessening the dependency on synthetic fertilizers. The closed-loop relationship between waste and fertilizer in plantation can be seen on WCR1, WCR4 & WCR8. Based on this relationship, the waste from mills & plantation, specifically POME (Palm oil mill effluent), EFB (Empty fruit bunches), and OPF (Oil palm frond) can be utilized as fertilizers sources.

On top of mitigating GHG emissions from the two largest sources, this circular arrangement also decreases the necessity for synthetic fertilizers—leading to substantial reductions in expenditure costs. This is particularly significant considering the staggering 300% increase in fertilizer prices in 2022 compared to the preceding year. (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

Table II1 Carbon emission data of plantation & mill value chain without LULUC

Carbon Emission Data (Without LULUC)		
Source of Emission	kg CO^{2}-eq/100 kg produced CPO	Proportion
Plantation		
Fertilzer	**6.480**	**22.58%**
Pesticide	0.037	0.13%
Energy	1.082	3.77%
Transportation	0.752	2.62%
Plantation Infrastructure	1.022	3.56%
Others*	19.326	67.34%
TOTAL EMISSION FROM PLANTATION VALUE CHAIN ONLY	28.7	kg CO_2-eq/100 kg produced CPO
Mill Value Chain		
Waste	**92.9**	**44.90%**
Wastewater treatment	**10.1**	**4.90%**
Energy	1.9	0.93%
Others*	102.0	49.27%
TOTAL EMISSION FROM MILL VALUE CHAIN ONLY	207	kg CO^{2}-eq/100 kg produced CPO

*Comprises of numerous small emission

In addition to enhancing soil quality, mill waste serves as a valuable resource for generating power and electricity, catering to energy requirements across all operational aspects. This is evident in WCR2, which converts POME into biogas for electricity generation, WCR3 which utilizes POME to produce biomethane or bio-CNG for fuelling plantation trucks, and WCR5 & WCR6 which transform fiber and shell into biomass fuel to power trucks in plantations and serve as boiler fuel in mills. Wastes with limited applicability or low utilization rates, when converted into fertilizer or energy, can also explore alternatives such as creating value-added products like handicrafts from OPF to maximize potential profits. Detailed insights into the potential impact of each waste reduction opportunity are outlined in Table II2.

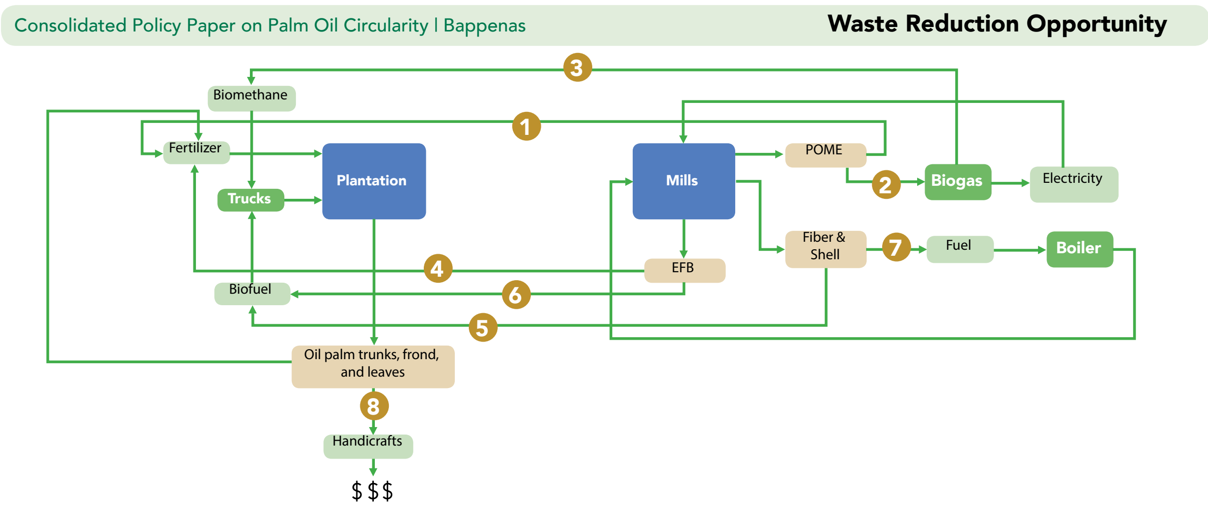


Figure II10 Waste reduction opportunity (number represents the number associated in WCR table)

The impact assessment outlined in Table II2 indicates that all initiatives aimed at reducing waste have the potential to decrease GHG emissions, cut costs, and enhance overall productivity. This underscores how implementing a circular economy model will significantly impact the performance of palm oil plantations.

Table II2 Waste reduction opportunity in plantation and mill value chain

No	Waste Reduction Opportunity	Emission Reduced		Impact
		Plantation	Mill	
WCR1	Conversion of POME into Fertilizer for soil health treatment	Fertilizer	POME Waste	• Decrease chemical fertilizer utilization by 58.7%-64.91% (smallholder) & 34.4%-86.68% (corporate) • Reduce fertilizer expenditure cost by 63.3% (smallholder) & 85.57% (corporate) • Obtain higher profit by 41.64% • Enhance FFB productivity by 14.29% • Reduce GHG emission by 65% (smallholder) and 96.4% (corporate) if chemical fertilizer is entirely replaced by POME
WCR2	Conversion of POME into biogas for electricity production	-	POME Waste, Electricity needs	• Reduce electricity cost • Reduce GHG Emissions by 75%
WCR3	Conversion of POME into biomethane for fuel of palm oil plantation trucks	Transportation	POME Waste	• Cut 10003 tCO2 emissions • Save 3.7M Liters of diesel
WCR4	Conversion of EFB into Fertilizer for soil health treatment	Fertilizer	EFB Waste	• Reduce chemical fertilizer utilization by 34.39% • Reduce fertilizer expenditure cost by 54.41%
WCR5	Conversion of fiber & shell into biomass fuel (biofuel) for palm oil plantation trucks	Transportation	Fiber & Shell Waste	• Reduce greenhouse gas emission • Reduce electricity use
WCR6	Conversion of fiber & shell into boiler fuel	-	Fiber & Shell Waste	• Reduce carbon emissions in boiler operations by 2.31% • Replace approximately 90% of the solar function in operating the boiler
WCR7	Conversion of palm oil trunks, frond, and leaves into handicrafts	Palm oil trunks, front, and leaves waste	-	Additional income from handicrafts
WCR8	Conversion of palm oil trunks, frond, and leaves into fertilizer	Palm oil trunks, front, and leaves waste	-	Reduce chemical fertilizer utilization & expenditure

2.3.1.2 Resource Efficiency

Other than activities directly correlated with waste optimization, greenhouse gas emission in palm oil plantations can also be further reduced through resource efficiency initiatives. While waste reduction focuses more on strategies related to the extension of product lifespan and the useful application of materials (R3-R9: Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover), resource efficiency focuses more on smarter product use and manufacture (R0-R2: Refuse, Rethink, Reduce). Potential resource efficiency (RE) efforts in the plantation and mill value chain can be seen in Table II3.

On some occasions, palm oil plantations are unsuitable for palm oil to grow naturally and therefore requires more intensive treatment (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). This intensive care can lead to increased greenhouse gases and scarcity of water resources (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Therefore, ensuring that palm oil is planted on suitable land is important to optimize resource allocation in the plantation, as mentioned in RE1. Using high-yielding palm oil varieties also has the potential to reduce the quantity of resources needed to produce the same amount of FFBs as mentioned in RE2.

The plantation soil consists of 40% Alluvial and 60% peat soil, which, without proper remediation and fertilization, lacks fertility and requires excessive use of inorganic fertilizers (Lugito & Saputera). As indicated in RE3, meticulous attention to the timing, dosage, and application method of fertilizers could potentially reduce the reliance on both organic and inorganic fertilizers by 55-60% (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). However, fertilizers still play a crucial factor in boosting productivity (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Integrating nitrogen-rich plants like Legumes into the plantation or integrating cattle, whose manure can be converted into natural fertilizer, further contributes to reducing the necessity for synthetic fertilizers while enhancing soil quality.

At present, mills are typically centralized, positioned around 40-50 km from plantations. This setup not only limits transportation optimization potential but also substantially contributes to more greenhouse gas emissions and transportation expenses. Therefore, decentralizing mills, as mentioned in RE7, becomes essential. Besides controlling mill locations, ensuring the quality of Fresh Fruit Bunches (FFBs) entering the milling process is also crucial to obtain higher yields of CPO (RE8). After optimizing the input(s) for mills, the process in mills need to also be optimized. Process improvements involve substituting current facilities with new ones that employ dry technology (RE9) or methods that eliminate the use of chemical substances (RE10), thereby streamlining milling processes and reducing liquid-based waste from mills. Losses in the milling processes also necessitate technological and digital optimizations (RE11 and RE12) to detect and prevent problems, ultimately resulting in reduced CPO losses. Consequently, these collective efforts result in reduced greenhouse gas emissions while maintaining—or even improving outputs from mill value chain.

Table II3 Resource efficiency opportunities

No	Aspects	Resource Efficiency Initiatives	Emission Reduced		Efficiency achieved and Advantage
			Plantation	Mill	
Plantation					
RE1	Land	Plant trees on suitable land areas, not on lands that are unsuitable as natural growth place for palm oil	Fertilizer, Plantation Infrastructure	-	Prevent the need for more intensive treatment
RE2	Seeds	Use high-yielding palm oil varieties and superior seeds to increase yields and plant productivity.	ALL	-	Increase yields from 15.2 ton/ha-year to 22.8 ton/ha-year

No	Aspects	Resource Efficiency Initiatives	Emission Reduced		Efficiency achieved and Advantage
			Plantation	Mill	
RE3	Fertili-zation	Utilize advanced fertilizer technology like FOSS NIR DA2500 to enable precise application and encourage intensive use among small-scale farmers and cooperatives	Fertilizer	-	Reduce the use of organic and inorganic fertilizer by 55-60%.
RE4	Pesticide	Using owl as rat pest natural predators	Pesticide	-	Reduce expenditure cost by 80% in palm oil plantation compared to rodenticide utilization or chemical monitoring
RE5	Agro-forestry	Utilizing legume crops that store nitrogen in nodules on the roots to naturally supply several essential elements for palm oil plants	Fertilizer	-	• Minimize the use of chemical fertilizers • Fix atmospheric nitrogen & provide nitrogen source for the soil to be used by future crops (150 kg N/ha) • Protection from soil erosion • Perform as cover crops to prevent water shortages
RE6	Silvo-pasture	Palm oil-cattle integration (conversion of cattle manure into fertilizer for soil health treatment)	Fertilizer	-	• Reduce chemical fertilizer expenditure by 56.68% • Decrease chemical fertilizer utilization by 47.71% • Increase profit 43.46%
Mill					
RE7	Mill Location	Mill facilities decentralization to reduce CO2 emission and cost from transportation activities.	Transportation	-	Reduce emission & transportation cost
RE8	Quality Control	Controlling the quality of FFB that goes into the milling process that goes to the milling processing	-	ALL	Obtain FFBs with high yield rate
RE9	Steriliza-tion Process	Development of dry process-based technology "Steam-less Palm Oil Technology (SPOT)" to change existing sterilization concept (wet process)	-	Steriliza-tion	• Reduce production cost by 18 • Reduce Greenhouse gas emission by 80%
RE10	Stripping Process	Avoid the use of chemical substances in the process of separating the palm kernel from its shell by using clay bath technology.	-	POME Waste	Reduce GHG Emission and obtain FFBs with higher yield

No	Aspects	Resource Efficiency Initiatives	Emission Reduced		Efficiency achieved and Advantage
			Plantation	Mill	
RE11	Process Optimi-zation	Apply digitalization or semi-digitalization to quickly and precisely detect the problem of CPO production processes.	-	ALL	• Help milling companies enhance the efficiency of the production processes. • Reduce labor force by about 20% and thus reduce operational cost by 20% too
RE12		Utilize FOSS NIR DA1650 analyzer for detecting oil loss	-	Product Waste	• Minimize oil loss during the process in a real-time manner • Reduce oil loss to below 0.7% or lower

2.3.1.3 Green Jobs

Waste management in the palm oil industry, specifically the utilization of by-products from cultivation and milling, is predominantly implemented by larger palm estates with integrated farm-to-mill operations. These estates have nearly achieved complete circularity in their processes. However, smallholders encounter obstacles in embracing circular economy practices. They lack access to knowledge, technology, and funds, limiting them to simpler strategies like the direct land application of waste or collaboration with others. Companies possessing more resources are inclined to engage in more innovative endeavours, exploring possibilities that demand substantial capital investment and the incorporation of new technologies for achieving circular integration.

The adoption of circular strategies involves changes in operational procedures, organizational structure, and sometimes the creation of new business units. Plantation & mill green jobs opportunity on Figure II11 are essential in ensuring the successful implementation of plantation & mill initiatives. Figure II11 also shows how different green jobs can be rated based on their circularity and work decency. Jobs that score high on both criteria are labelled as "Dark" green, while jobs that score high on one and low on the other are labelled as "Medium" green. Jobs that score low on both criteria are labelled as "Light" green.

Plantation & Mill green jobs' opportunity mapping

Initiatives	Circular Jobs	Work decency likeliness	Job impact type	Shade of green
Recovery (R9) Incineration of by -product for energy briquetting solid waste for co-firingt WCR/ RE Opportunities: WCR 5, WCR 6	Product design Waste processing Machinery operation Trading by-product for bioenergy	Above minimum national standard	Job transformation or creation	Medium
Repurpose (R7) Methane capture from POME for biogas WCR/ RE Opportunities: WCR 2, WCR 3	- Product design - Waste processing - Machinery operation	Above minimum national standard	Job creation or substitution	Medium
Repurpose (R7) Utilize by - product for other product WCR/RE Opportunities: WCR 7	- Material & product design & development - Product development - Product marketing	Above minimum national standard	Job transformation	Medium
Reuse (R3) Utilize by - product for biofertilizer (EFB, Shells, Fiber, POME) WCR/RE Opportunities: WCR 1, WCR 4, WCR 8	- Circular product design - Biofertilizer production - Biofertilizer application	Meeting minimum national standard	Job transformation	Medium
Reduce (R2) Advancing Cultivation Technique Optimizing legume Precision in fertilizer Water & pest management WCR/ RE Opportunities: RE3, RE4, RE5	- Material and methodology design & development - Implementation of new technique	Meeting minimum national standard	Job transformation	Medium
Rethink (R1) Development of small - scale SPOT milling facilities WCR/ RE Opportunities: RE9	- Business development - Construction - Business management - Facilities operation - Sales & marketing	Meeting minimum national standard	Job creation or substitution	Medium
Rethink (1) Share economy in the plantation - Intercropping - Cattle Parm Farming WCR /RE Opportunities: RE9	- Business development - Methodology design & development - Agricultural/ Cattle-farm supervisor - Intercrop/ Cattle Farmer - Supply Chain Management	Meeting minimum national standard	Job creation or substitution	Medium

Source: International Labour Organization

Legend: High Low

Figure II11 Plantation & Mill green jobs opportunity mapping

Data from Ministry of Agriculture shows that the upstream chain especially in the plantation, absorbs more workers than the downstream. Depending on the effectiveness, a medium to big plantation usually employ 1 labourer for 5-7 hectares (or 0.2 – 0.15 ratio) while smallholders are much lower with 1 labourer for 2 hectares (or 0.5 ratio).

This number does not reflect higher job creation opportunity, but rather lower productivity due to famer's limited capacity and capability in smallholder plantation. Research conducted by BAPPENAS with the support of Denmark Embassy and UNDP shows that there might be a trend of job shifting, where some jobs in the upstream value chain will be displaced but the downstream chain will anticipate jobs creation. Given this projection, this report emphasizes the need for a skilling policy to support the transition of jobs by retraining displaced workers to fill new roles created by the circular transition.

2.3.1.4 Fiscal and non-Fiscal Stimulus

Implementing a circular economy within the palm oil value chain requires the adoption of various strategies, including the improvement of plantation productivity by adhering to through compliance with Indonesian Sustainable Palm Oil (ISPO) standards. However, as of March 31, 2021, the Ministry of Agriculture reported only 755 plantations certified under ISPO. Among these, 668 belong to private companies, 67 to state-owned entities, and 20 to smallholder plantations, covering 5.8 million hectares out of 16.38 million hectares of national palm oil plantations, constituting 35.4% of the total. The limited number of certifications is primarily due to the relatively high costs, especially burdensome for smallholder farmers. Additionally, technical obstacles such as challenges in smallholders' land legality and the complexities involved in the ISPO certification process, further impede widespread adoption. Furthermore, the absence of compelling business incentives also discourages farmers from pursuing ISPO certification. Table II4 presents a list of fiscal or non-fiscal incentives to address these issues.

Table II4 Fiscal and Non-Fiscal Stimulus for CE implementation in plantation & milling value chain

Implementation	Traits/Obstacles	Incentives	Key Stakeholder	Targeted Stakeholder
Have higher productivity of oil palm plantations through compliance with ISPO Instruments: a) Presidential Regulation No. 44/2020 on the Certification System for Sustainable Palm Oil Plantation in Indonesia b) Regulation of the Minister of Agriculture of the Republic of Indonesia Number 38 Year 2020 on the implementation of certification of Indonesian Sustainable Palm Oil Plantations	Cost and legal administration of ISPO is significant for small farmers.	Non-Fiscal Provide sufficient subsidies for small and privately owned plantations which have clear legality of land to obtain and renew ISPO certificate	BPDKS	Smallholder Farmers
		Non-Fiscal Provide affordable financing schemes for ISPO certification such as through KUR (Business Credit for Micro and Small Enterprises) and UMI (Financing for Ultra Micro Enterprise)	Financial Services Authority (OJK) and Financial Institutions	Smallholder Farmers
	The ISPO certificate process takes quite a long time as it is only managed by a few people (PTPN III).	Non-Fiscal 1) Simplify certification process and provide training and resources to help farmers understand the benefits of ISPO certification and how to obtain it 2) Fund ISPO certification fee assistance for smallholders through APBN, APBD and ohtther sources as per relevant laws and regulations 3) Provide counseling related to CE applications to farmers.	Ministry of Agriculture	Smallholder Farmers
	No difference in purchase price between ISPO-certified and non-ISPO certified farmers (APKASINDO)	Fiscal Reduce export excise tax for companies that purchase ISPO-based products at higher prices to establish price differential between ISPO and non-ISPO-certified products.	Ministry of Finance	Companies & Farmers

To make the plantation value chain more sustainable, some key conditions need to be met. These are: educating smallholders on how ISPO certification can benefit them and what they need to do to get it, which can boost the demand for ISPO-certified products. Also, ensuring that smallholder farmers have legal rights to their land, which can help them get subsidies for ISPO certification. Moreover, creating a common vision among important actors like the Ministry of Finance, the OJK, and banks, on why circular economy is important and how to implement it.

Implementing circular economy (CE) in milling value chain often means repurposing waste into fertilizers or other usable products within the plantation & milling value chain. Despite the economic benefits of using by-products for other activities and achieving circularity, setting up infrastructure for waste utilization involves significant initial investment costs. Additionally, there's a lack of financial incentives that would offset these high initial expenses for companies adopting circular economy practices in their operations. Consequently, government support, both in terms of fiscal and non-fiscal incentives, becomes crucial to optimize waste utilization efforts. Therefore, such support is crucial in alleviating the financial strain and guaranteeing the realization of circular economy practices within the milling value chain.

Table II5 Fiscal and non-Fiscal Stimulus for CE implementation in milling value chain

Implementation	Traits/Obstacles	Incentives	Key Stakeholders	Targeted Stakeholders
Using plant waste as fertilizer and energy through the following efforts: a) EFB utilization as organic fertilizer & compost to improve Ultisol Subsoil and serve as a ground cover to retain moisture [WCR4] b) POME utilization as liquid palm fertilizer which makes palm oil trees more fruitful [WCR1] c) Utilizing POME for electricity generation through methane capture technology aimed at producing Biogas [WCR2] d) Transforming biogas derived from POME into bio-CNG to fuel trucks within palm oil plantations [WCR3]	(a), (b), (c), & (d): Reuse of waste decisions depends on cost efficiency consideration (Wilmar Group).	**Fiscal** Reduce corporate income tax and/or reduce export excise tax for companies using circular products, such as palm bunch ash and POME-based fertilizers in the plantation.	Ministry of Finance	Companies
		Fiscal Reduce VAT and/or corporate income tax for palm oil industries which adopt repair and reuse practices in their production	Ministry of Finance	Manufacturing Companies
	(a), (b), (c), & (d): Inadequate supervision of milling waste regulation.	**Non-Fiscal** Provide business license issuance mechanism to control wastewater discharges	Investment Coordinating Board (BKPM), Ministry of Environment and Forestry, and District Government	Companies
	(b), (c), & (d): The installation of POME requires a relatively high cost. Meanwhile, at domestic level, a clear market for the "green production" product still does not exist (Wilmar Group).	**Fiscal** Provide incentives for companies to build POME treatment installation, such as import duty free for POME installation capital goods (e.g. Boiler) and/or tax allowance	Ministry of Finance	Manufacturing companies, especially small and medium scale industry
		Non-Fiscal Provide affordable financing schemes for POME treatment installation such as through KUR and UMI	Financial Services Authority (OJK) and financial institutions	Small and medium scale manufacturing companies
		Non-Fiscal Provide funding for RnD in palm oil based circular economy such as POME treatment and biodiesel production at a lower cost	BPDKS	Manufacturing companies, research, and academic institutions
	(c): PLN purchases biogas energy sources at low level, which is the same as the DMO of coal, thus for company sides selling prices of biogas energy are lower than the production cost (PTPN III).	**Non-Fiscal** Encourage utilization of biomass from POME as an energy input for PLN, with a competitive tariff	Ministry of energy and mineral resources, PLN	Manufacturing companies

To adopt circular economy in the milling value chain, it is important that all the parties involved agree on its necessity and work together to implement it. The government supports this by setting limits on waste generation, regulating POME treatment, and offering incentives. Moreover, the Financial Services Authority (OJK) makes it easier for companies to access funds for circular economy projects, which helps to build more facilities for managing waste in the mill value chain.

2.3.2 Refinery Value Chain

Palm oil refining involves two main categories: physical and chemical purification or refining (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Physical purification is divided into two stages: pre-treatment and deodorization (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The pre-treatment stage aims to remove unwanted impurities that impact the final oil product's stability (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). This stage involves degumming and bleaching of palm oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023) using phosphoric acid and bleaching earth (Irawan & Hasan, 2021) to react and absorb unwanted impurities.

Degumming aims to separate gum, latex, and mucilage (phospholipids, proteins, residues, and carbohydrates) in oil without reducing the amount of oil-free fatty acids (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). It involves separating phosphatides into the water phase so that it can be separated by precipitation, filtering or centrifugation (Gibon, De Greyt, & Kellens, 2007) (Ketaren, 1986). Various degumming methods include water degumming, acid degumming, dry degumming, and enzymatic degumming (Sim, et al., 2018). Water degumming removes phosphatides in Crude Palm Oil (CPO) using water (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Acid degumming uses phosphoric acid or citric acid (with 2-5% water) at a temperature range of about 80 to 90 °C (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). In dry degumming, CPO is mixed with 0,05% to 0,10% concentrated phosphoric acid and heated to about 80 to 110 °C (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Enzymatic degumming uses phospholipid degrading enzymes called phospholipases (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Water and acid degumming are more widely used in the cooking oil industry due to their economic feasibility, safe in large quantities, and easy availability (Anderson, 2005).

Bleaching aims to reduce beta-carotene levels and oil deterioration of bleachability index (DOBI) levels to maintain the color quality of the produced products (Anderson, 2005) and to remove traces of metals, color pigments, phosphatides, and other impurities (Silvia, et al., 2013). The bleaching process reduces the color of CPO from brown to clear yellow, eliminating residual dirt, latex gum, and residual free fatty acids (FFA, also known as *asam lemak bebas* or ALB) (Amelia, et al., 2023) to achieve the desired characteristics of refined vegetable oils (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). During the bleaching process, the oil is heated with various types of bleach clay or bleach earth at temperatures between 85 and 110 °C in a vacuum condition (720 mm Hg to 760 mm Hg) (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Commonly used bleach clay or bleach earth include bleaching acid-activated earth, fuller's earth, and activated charcoal (Silvia, et al., 2013).

In the last stage of physical purification, deodorization, the oil that has undergone previous processing is deacidified and deodorized (Anderson, 2005). Before being pumped into deodorizer, the oil undergoes dehydration and heating to 240 to 270 °C using a heat exchanger under vacuum conditions (2-5 mm Hg) (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Temperatures above 270 °C are avoided to minimize the loss of neutral oil, tocopherols/tocotrienols, and the risk of isomerization and unwanted reactions (Ayustaningwarno, 2012) (Bailey & Worrell, 2005). Under these conditions, with the assistance of stripping steam, the remaining FFA in the pretated oil, are distilled together with more volatile odoriferous compounds and oxidation products such as aldehydes and ketones which can impart an undesirable odor and taste to the oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). At the same time, carotenoid residues are decomposed, generating light-colored or bland Refined, Bleached, & Deodorized (RDB) oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). To maximize heat energy recovery, deodorized hot oil is brought into contact with pretreated oil up to temperatures of 120 – 150 °C using the heat exchanger (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

Further cooling is achieved with water to a temperature of 55 – 65 °C before proceeding to the storage tank (Damarani, Sholihah, Zullaikah, & Rachimoellah, 2019). The three stages of physical purification are illustrated by Figure II12.

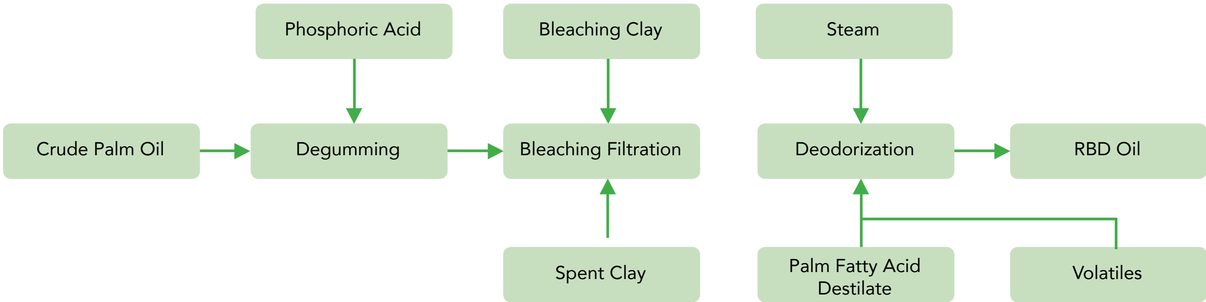


Figure II12 Flowchart of Physical Purification

(Ayustaningwarno, 2012)

Compared to physical purification, chemical purification involves three additional stages: neutralization, centrifugation, and drying (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Therefore, chemical purification is divided into six stages: degumming (gum condition), neutralization, centrifugation, drying, bleaching, and deodorization (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). In degumming stage, CPO is heated to a temperature of 80 – 90 °C, and then phosphoric acid with a concentration of 80 – 85 percent is added at a rate of 0.05 – 0.2 percent of the feed rate of CPO (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Subsequently, the degummed oil is treated with an excess caustic soda solution (NaOH) (approximately 20 percent based on the FFA content in the crude oil) (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

On the other hand, neutralization converts FFA in the degummed oil into soap, creating a soapy mixture of fatty acids, salts, phospholipids, impurities, and neutral oils (Gibon, De Greyt, & Kellens, 2007). sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium bicarbonate ($NaHCO_3$), and sodium carbonate (Na_2CO_3) are the main alkaline reagents used in this stage (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The neutralization stage involves gravity settling followed by the separation of the soap stock from the neutralized oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Then, hot water is used to clean alkaline residue from the oil system (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). To remove any remaining soap, Neutralized Palm Oil (NPO) is washed with 10 – 20 percent hot water (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Afterwards, the oil is separated from the washed soap through centrifugation process and then vacuum dried until the moisture level is less than 0.05 percent (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

NPO then undergoes the bleaching and filtration stages, treated with bleach earth, and the deodorization stage follows the same treatment as in physical refining (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The oil is then distilled at 240 – 260 °C and a vacuum pressure 2 – 5 mm Hg by the direct method steam injection to remove residual FFA, volatile oxidation products, and odoriferous material (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The final product, Neutralized, Bleached, Deodorized (NBD) oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023), is then cooled to a temperature of 60 °C and passed through a polishing filter bag before being pumped into a storage tank (Ayustaningwarno, 2012). The six stages of chemical purification are illustrated by **Figure II13**.

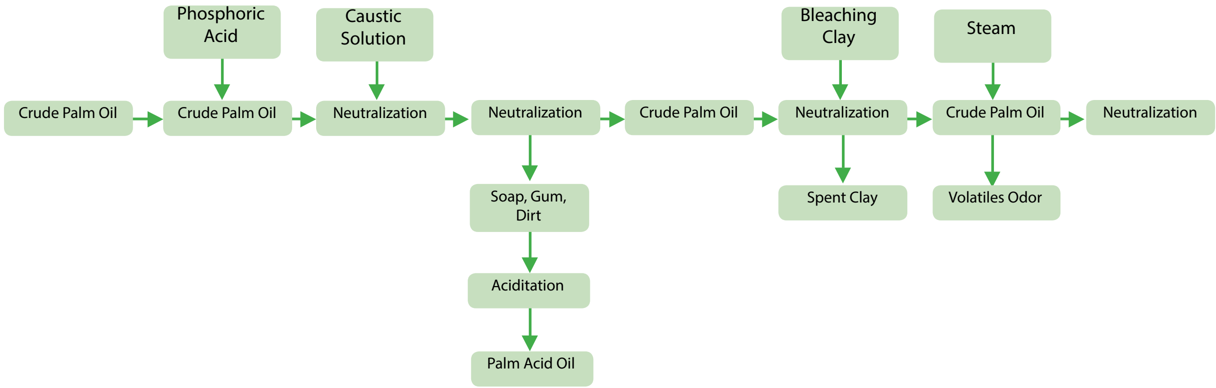


Figure II13 Flowchart of Chemical Purification

(Ayustaningwarno, 2012)

In addition, the biorefining process involves the continuous conversion of biomass into various biofuel-based products (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The process aims to harness biomass energy for thermal energy generation, electricity, and biofuel (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Over the past decade, biomass has been utilized to produce a range of products beyond biofuels, including fine chemicals, biomaterials, biopolymers, etc. (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

2.3.2.1 Waste and CO2 Reduction

The production of cooking oil (refined palm oil olein) from Indonesian palm oil refinery industry reached 15.5 MMt in 2009 (see Table II6). This production has experienced rapid growth, surpassing the growth of consumption (Lugito & Saputera).

As a result, palm cooking oil local food consumption in Indonesia in 2021 was about 26,.5 kg cooking oil per capita per year, accounting for about 8.95 MMt or almost 20% of Indonesia's CPO production (Statista, 2021). According to a Publication in the Food Consumption Bulletin of the Ministry of Agriculture (2019), the production of palm cooking oil in Indonesia can meet the overall national consumption and can even be exported abroad, with an estimated volume of 20.36 MMt. Data from the Large-Medium Industry (*Industri Besar Sedang*) indicates the presence of 74 palm cooking oil factories in Indonesia, with 45 of them concentrated on Sumatra and Java Islands (see Figure II14).

Table II6 Production Capacity and Market Share of Cooking Oil Industry Industries in 2009

Source: Profil Komoditas Minyak Goreng, Kemenperin (2009)

No	Shareholders	Production Capacity (ton/year)	Market Share (%)
1	Wilmar Group (5 companies)	2,819,400	18,24
2	Musim Mas (6 companies)	2,109,000	13.64
3	Permata Hijau	932,000	6.03
4	PT Smart	713,027	4.61

No	Shareholders	Production Capacity (ton/year)	Market Share (%)
5	Salim Group	654,900	4.24
6	PT Bina Karya Prima	370,000	2.39
7	PT Tunas Baru Lampung (Sungai Budi Group)	355,940	2.30
8	BEST Group	341,500	2.21
9	PT Pacific Palmindo Industri	310,800	2.01
10	PT Asian Agro Agung Jaya (RGM Group)	307,396	1.99
11	Others	6,542,637	42.33
Total		**15,456,600**	**100.00**

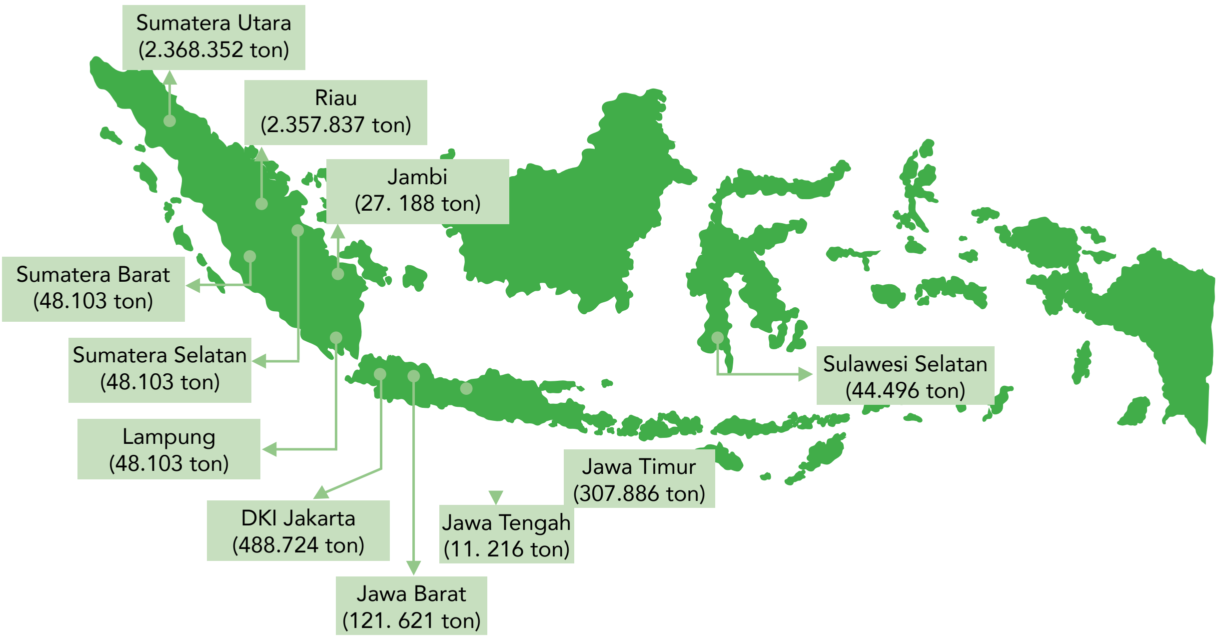


Figure II14 Indonesian Palm Oil Refinery Industry Profile

Source: BPS (2021)

A life cycle assessment has been conducted for refinery, assuming that 20% of refined CPO (21% CPO) was processed to meet the local cooking oil demand, estimated to be 6 MMt in 2022 (Nemecek & Schnetzer, 2012). The palm oil refinery encompasses degumming, bleaching, deacidification, deodorization, and fractionation of CPO into 4.5% Palm Fatty Acid Distillates (PFAD). Emissions from the refinery result from steam and energy generation, the utilization of phosphoric acid and bleaching earth, as well as the transportation of CPO and chemicals.

The network assessment of palm oil refinery, utilizing aSn Indonesian background database including Land Use and Land-Use Changes (LULUC) and foreground data excluding LULUC, reveals that the refinery process contributes only 5.05 kg of CO_2-eq/100 kg produced CPO. This contribution comprises of steam and energy generation (42.9%), bleaching earth production (30.7%), and transportation (25.1%) (Lugito & Saputera). Primary data from PT. SMART was used for calculating the Life Cycle Impact Assessment in this chain, employing software excluding LULUC. The result indicates that the refinery has the lowest contribution impact to Global Warming Potential (GWP) compared to palm plantation and mill values. The CO_2 equivalent, calculated by the software with a functional unit of 100 kg CPO, shows that the refinery contributes for 6.69 kg CO_2 eq emissions. On the other hand, this chain also produces other impacts, such as acidification, eutrophication, abiotic depletion, and water toxicity.

The impact of GWP is among the highest impacts from the refinery. Based on impact assessment, the refinery represents the lowest contribution for GWP concentration. This results in the total amount of chemicals used in this chain being only 0.935 kg to produce 100 kg CPO.

In the refinery value chain, the amount of chemicals used is smaller than in palm plantation and mill values for 100 kg CPO production. Based on GWP specification, the result indicates that carbon monoxide is the highest contributor affecting global warming, contributing 1.31 kg CO_2 eq emission from total concentration GWP for 6.69 kg CO_2 eq emission. This emphasizes the significant impact of carbon monoxide on atmosphere conditions and global warming. Thus, the software calculation of background data and foreground data from PT. SMART shows that refineries make the lowest contribution to GWP than palm plantation and mill value chains. To encourage the palm oil industry's refinery value chain, several strategies can be implemented: (1) improving chemical usage efficiency, (2) optimizing the bleaching process, (3) employing a dry process to reduce liquid-based waste, and (4) decentralizing refinery facilities.

2.3.2.2 Resource Efficiency

The number of palm oil refinery in Indonesia has reached 86 units with a capacity of 56 million tons/year (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). In addition, there are also 19 units biodiesel industry with a capacity of 12 million kiloliters/year and 21 units oleochemical industry with a capacity of 11.3 million tons/year (Ristiningsih, Sutijan, & Budiman, 2011). Circular economy practices in the process of refining CPO have relatively large impact (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). The use of hot steam can reduce costs by up to 39.29 percent and the use of electricity can reduce costs by up to 13.47 percent (Kongsager, Rico, Napier, & Mertz, 2013). The refinery companies produce solid waste in the form of Spent Bleaching Earth (SBE) (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

Figure II15 Circular Economy Practices for Spent Bleaching Oil

Within the refinery process, the circularity strategies identified by the LCA-WCR analysis mostly involve changes in technology or mechanism to process CPO into palm cooking oil (ILO, 2023). Data from GIMNI (Indonesian Vegetable Oil Association) state that some of their members, especially top refinery groups have been implementing these strategies such as dry fractionation, the use of chemical for refinery, and oil modification (GIMNI). These mechanisms are believed to be more efficient and can improve the quality of the product. In addition, the Steamless Palm Oil Technology (SPOT) can be implemented for refinery processes. This technology allows palm extraction through pasteurization, eliminating the bleaching process. It also enables the development of refinery plants around the plantation without the requirement to be near a water source (such as river) like the conventional technology – allowing decentralization of refinery facilities. Nevertheless, the implementation of the SPOT for cooking palm oil processing is still limited, so its potential is not understood yet.

A recent regulation change that excludes Spent Bleached Earth (SBE) – solid waste from refinery process of palm cooking oil, from hazardous waste, also provides an opportunity for circularity (GIMNI, 2021). The SBE can be processed to produce recovered oil (R-oil) dan De-Oiled Bleaching Earth (OBE) which has potential as export commodity.

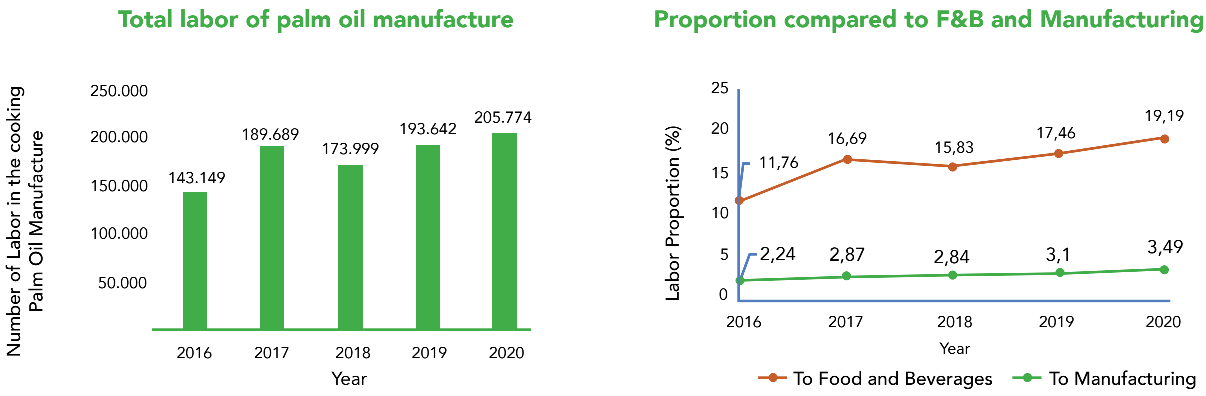
With current production capacity of national refineries, GIMNI estimates that Indonesia will need 17 SBE facilities. However, in the past five years, only two out of three available facilities are operating (Okezone). Nevertheless, the development is not without criticism; environmental NGOs are concerned that the regulation will enable refineries to avoid treating the hazardous waste, endangering the surrounding community and environment (BBC Indonesia, 2021).

2.3.2.3 Green Jobs

Like the milling process, the work in the refinery is highly automated and therefore it is a capital-intensive industry (ILO, 2023). Unlike plantations and millings that are dispersed, a relatively small number of large corporate groups control Indonesian oil palm refineries and the export market, with the five largest groups controlling about two-thirds of the total refining capacity and export volume (Trase; Auriga; University of California, 2020). Data from Trase shows that in 2020, there are 85 refineries owned by 57 companies that are controlled by 35 groups (ILO, 2023).

Using data from the National Statistics on Medium and Big manufacturing industry, the UNDP-KIREI's study estimates that in 2020, cooking palm oil manufacture employed around two hundred workers (ILO, 2023). Figure II16 shows a stable increase of workers from the past years, showing the sector resilience during the COVID-19 pandemic. Although relatively small compared to the number of labours in the plantations, this number represent almost 20% workers from Food and Beverages Industry and 3.5% of total employment from manufacturing sector.

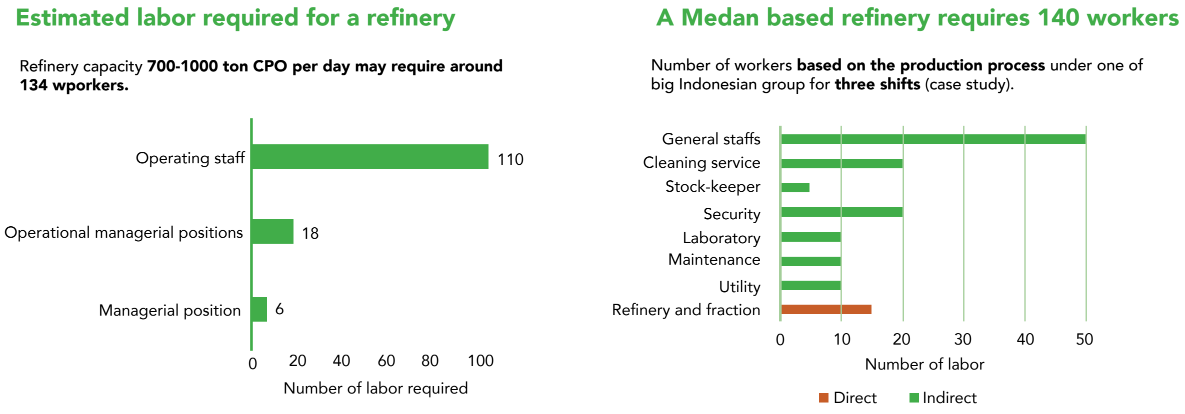
The sector resiliency during the COVID-19 pandemic



Source: International Labour Organization

Figure II16 The Sector Resiliency During the COVID-19 Pandemic

A refinery with capacity for 700-1000-ton CPO per day may require around 134 workers that includes six managerial position, 18 operational managerial positions, and the rest are operational staff ranging from machine operator to cleaning services (Mariati, 2007). Based on the production process, a case study in a Medan based refinery under one of big Indonesian group documents that the direct personnel's needs for the plant for each shift are each 15 for refinery and fractionation operations; while for the indirect personnel, the number of workers required are 10 for utility, 10 for maintenance, 10 for laboratory, 20 for security, 5 for stock-keeper, 20 for cleaning service, and 50 for general staffs (Aritonang and Sucini, 2020), as shown in Figure II17. The plant operation is divided into three shifts and the remuneration system is based on the contractual type of the workers. The remuneration component includes monthly wages and daily incentives, determined based on skill, merit, and position.



Source: International Labor Organization

Figure II17 Workers Requirement for a Refinery

In general, refineries offer better quality employment compared to plantations. The workers are employed as either permanent workers, or a temporary worker – mostly for the supporting process. They enjoy guarantees for decent wages, proper labor protection, and freedom of association. Like mills, several positions on the refineries are subject to certification under Ministry of Manpower regulation No. 395 of 2014. The economic scale and capacity of the refineries also enable them to attract skilled workers. Companies provide access to training and career development, including when they introduce new machinery, technology, or approach/ system.

Moreover, since most of the refineries in Indonesia are affiliated with major palm oil group which supply not only domestic but also international market, most of them are also adhering to sustainability practice including ISPO, RSPO, and the ZDCs. These pledges also cover criteria that ensure decent working conditions. With the growing pressure for a sustainable palm oil, some major refineries (e.g. Golden Agri Group, Wilmar, also Musim Mas) and FMCGs (e.g. Nestle, Unilever, also Cargill) initiated programs in ensuring human and labor rights for their palm oil supply chain as part of their Environmental Social Governance (ESG) and often tied with the traceability effort under the ZDCs, and through market based collaborative program (e.g. the Decent Rural Living Initiative supported by Cargill, olden-Agri-Resources, Musim Mas, Sime Darby Plantation, and Wilmar).

The oligopolistic market structure of the refineries provides them with market power to encourage their supplier to also adhere to certain requirements and standards, and therefore provides an avenue to promote sustainable practices along the supply chain.

The introduction of circular strategies into the sector has brought changes in how work is organized within the related business process (ILO, 2023). The changes range from transformation of current functions to the establishment of new functions, depending on the innovations that were introduced. The changes resulting from increased circular practices can take place within current estates/actors in the supply chain, or in the newly established actors, depending on the business model. Figure II18 summarizes the relation between circular strategies and how it can affect jobs on the identified circular initiatives above in refinery value chain. Circular strategies not only change the jobs directly related to the business process in question, but also affect the jobs within the sector that provide services that enable the implementation of these circular strategies. These indirect functions include public service (mostly related to sanitation, waste management, and research and development), information services provider (especially for IT-based strategies), logistics services, and knowledge-intensive business services (researcher and trainer providers).

Refinery jobs' changing through circular strategies

Initiatives	Innovation	Innovation circular process	Changes in current function	Establishment of new function
Reduce (R2) Optimizing refinery process • Improve chemical usage efficiency • Optimized bleaching process • Dry fractionation	Product design	• Material and methodology design and development • Implemetation of new techique	• R&D[1] • Plant/refineries operator[2]	
Rethink (R1) Development of small-scale SPOT refineries	• Core technology • Socio-Instution	• Business development • Construction • Business management • Facilities operation • Sales & marketing		• SPOT refineries architecture and construction[1] • Business management[1] • Plant/refineries operator[2]
Repurpose (R7) Converting SBE into recovered oil (R-Oil) adn De-Oiled Bleaching Earth (OBE)	• Core technology • Product design	• Product design • Waste Processing • Sales and marketing	• R&D[1] • Waste management[2]	• SBE facilities operation[2] • Sales and marketing R-Oil and OBE[2]

Source: International Labor Organization

Legend: (1) Direct enabling jobs, (2) Direct core jobs

Figure II18 Refinery Jobs' Changing Through Circular Strategies

Source: (ILO, 2023)

The impact of circularity on jobs opens the opportunity for green jobs creation (ILO, 2023). Green jobs from circularity can come from greening current occupations or the creation of new jobs. This change can take place through different scenarios of job-impact type from circularities (see table 6), or the combination of them.

Table II7 Type of Employment Impact from Circularity in the Palm Cooking Oil Industry

Source: (ILO, 2023)

Type of Impact	Description
Job creation	Circularity will increase the demand for labors in some sectors/chains, generating new employment. For example, methane capture from POME activity requires biogas plant operators in the milling facilities, digitalization of waste management requires ICT system design, analyst, and developer.
Job substitution	Some employment opportunities will shift from the companies and sectors that are associated with linear to the circular model. This usually can be seen when there are new sharing economy platforms and new business models. For example, the intercropping cooperation between plantation and farmers moves the individual farmers from traditional farming into organized models facilitated by the Agro-Tech start-ups. Job elimination

Type of Impact	Description
Job elimination	Circularity will eliminate certain jobs where no direct replacement is available. This can be occurred when the circularity is implemented via automatization which not only eliminates certain tasks but also the job as it is being replaced by machinery. For example, when a plantation starts to mechanize the fertilizing process using bio-fertilizer which will reduce the workers significantly, or when digitalized waste collection is implemented massively reducing the opportunity of manual waste picker.
Job transformation and redefinition	Circularity transforms or redefines the existing jobs. This is the most common pattern observed in the palm cooking oil industry especially in the plantation, mill, and refinery. The use of solid and water waste as biofertilizer changes the process and method for waste treatment in the plant and fertilizing in the plantation, transforming the jobs of plant workers and maintenance workers in the plantation. This type of change will require new skills and retraining of those affected workers. A job transformation happens when the activities related to the circular works have been adopted to the business process. In common practice, within enterprise level this happens when the activities are adopted into SOP or established as the standardized process. In the informal economy, such as the smallholders, this can be seen when the activity became the common norm.

The employment characteristics and circular innovations applied in the refineries share the same pattern with palm mills (ILO, 2023). In the refineries, work is highly mechanized, and the CE strategies are implemented through product design and core equipment and machinery technology. In many cases, these initiatives are sustained by in-house continuous research and development where many refineries, especially major groups, have a dedicated R&D unit. In this instance increased circularity will mostly transform existing jobs, from the supporting function such as R&D, business development, sustainability, and within the product manufacturer in the operation. Like the mills, job creation will occur when the refineries develop new facilities to support the circular strategy, such as the development and operation of SBE processing facilities. The initiatives in developing small scale SPOT refineries may open opportunities for job creation in the manufacturing sector within rural areas where the palm plantation operated. As the scale of these refineries are smaller compared to the existing refineries' business model, it may be the case that the condition of work in this business model will be sub-optimal compared to the established and big-scale refineries. Based on these identifications, the green jobs opportunity from circularity in the cooking palm oil chain, especially in refinery value chain, can be summarized in the figure below.

Refinery green jobs' opportunity mapping

Initiatives	Circular Jobs	Work decency likeliness	Job impact type	Shade of green
Reduce (R2) Optimizing refinery process • Improve chemical usage efficiency • Optimized bleaching process • Dry fractionation	• Material and methodology design development • Implement pf new technology	Above minimum national standard	Job transformation or creation	Dark
Rethink (R1) Development of small-scale SPOT refineries	• Business development • Construction • Business management • Facilites operation • Sales & marketing	Meeting minimum national standard	Job creation or substitution	Medium
Repurpose (R7) Converting SBE into recovered oil (R-Oil) and De-Oiled Bleaching Earth (OBE)	• Product design • Waste processing • Sales & marketing	Above minimum national standard	Job creation or substitution	Medium

Source: International Labor Organization

Legend: High Low

Figure II19 Refinery Green Jobs' Opportunity Mapping

Source: (ILO, 2023)

Given the vast opportunity of green jobs from circularity in the refinery value chain, ensuring the decency of work for those employed to carry out these circularity process, both core and enabling circular jobs, will be critical in fully realizing this green job opportunity (ILO, 2023). Most of the potential employment change is likely to come from a job transformation, so empowering and ensuring that current enterprises are aware of and can uphold decent work principles will be essential. In addition, promoting formalization and ensuring the compliance of minimum national labor standard in the new business model introduced in the upstream and post consumption is also necessary to ensure that the circular job creation is a green job.

According to the interviews, a wide range of skills were needed to support the circular strategy within the refinery value chain. These skill requirements are diverse across jobs and affect functions throughout the supply chain. The modalities also depend on the job impact that was brought about by the increased circularity. A circular induced job transformation will require re-training to adjust the strategy into the existing operational procedures, while job creation (and substitution) will require a re-skilling of new and existing workers to fulfil the new function.

A generalization can be drawn to identify the skill requirement across the chain. This broad-brush identification is categorized based on the type of direct jobs (core and enabling) involved in the process and may differ in detail within the practice. Figure II-20 summarizes characteristics, related decent work challenges, and skill required for circularity in the palm oil refinery.

Circularity in the palm oil refinery

Characteristics

- Circularity is introduced to manufacturing process and self-reliant.
- Companies invest R&D to allow innovations including for CE.
- The strategy is capital intensive and use mechanized works.
- Workers are mostly permanent and skilled.
- CE mostly promoted jobs transformation.
- Company provides retraining and certification (when needed).

Related decent work challenges

- Current OSH concerns

Skills required

Enabling

- Circular anaytics, innovation, design
- Business planning and development
- Problem solving and critical thinking
- Enviromental awareness
- Waste management
- Energy efficiency
- Effective communication
- Strategic thinking
- Basic software
- Supply chain management
- Green construction

Core

- Environmental awareness
- Waste management
- Energy efficiency
- Process management
- Machinery operation
- Occupational Safety and Health (OSH)
- Collaboration and teamwork
- Willingness to learn

Source: International Labor Organization

Figure II20 Circularity in the Palm Oil Refinery

Source: (ILO, 2023)

Since the choice of circular strategy tends to be contextual with each enterprise's needs, generally the training is delivered through an in-house program especially for those involved in the core process (operating process workers) (ILO, 2023). In the plant, retraining occurs with the introduction of new technology, equipment, or facilities. Training is usually offered and carried out by the equipment manufacturers during installation, and companies will send their workers for certification when it is required by the regulation. Nevertheless, no specific job competency standards on green jobs in the palm oil sector are currently available, such as operator for Biogas Plant from POME (ILO, 2023). However, since the basic operation of the machinery does not require specific skills on circularity, enterprises perceive that current skill needs can be fulfilled either by retraining workers to operate with the updated technology or recruiting new workers with the adequate basic technical competences on plant operation.

2.3.2.4 Fiscal and Non-Fiscal Stimulus

UNEP does not address fiscal and non-fiscal stimulus aspects of refinery value chains

2.3.3 Packaging and Distribution Value Chain

Palm cooking oil, as one of the CPO derivative products, is circulating in the market in two types: bulk cooking oil and branded cooking oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Bulk cooking oil, or normal olein, is a one-stage fractionation product of palm oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). In contrast, branded cooking oil, or super olein, is two-stages fractionation product of palm oil (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Normal olein usually has an IOD number of 54.33 – 59.14 Wijs (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). Refined palm products, such as cooking oil in distribution must be packaged to improve cooking oil quality, safety, and health (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023). In the distribution process, packaging is a significant source of waste (Sambodo, Hidayat, Nurjanti, & Fauzi, 2023).

2.3.3.1 Waste and CO2 Reduction

Palm cooking oil packaging available in several forms, such as High-Density Polyethylene (HDPE) jerrycan, Polyethylene Terephthalate (PET) bottle, standing pouch, plastic glass, sachet, etc. (see **Figure II21**) (Lugito & Saputera). Specifications of each packaging are shown in Table II8. The aim is to evaluate the waste and CO_2 contribution of packaging in every kilogram of palm cooking oil production. Based on the criteria of resource reservation, complexity of production process and sales, 2 L bottle packaging contributes the highest value, followed by 1 L polyolefin pouch and 60 mL BOPP economical sachet packaging. Therefore, a comparison between the three packaging sizes has been conducted. The functional unit of 14.3 kg cooking oil is used for the calculation. Table II9 comprises the inventory databases used in the impact assessment of global warming as well as water consumption. Recycling of PP and PET as well as development of eco and biodegradable packaging, can encourage packaging and distribution value chain of the palm oil industry.

Figure II21 Palm Cooking Oil Packaging

Source: (Lugito & Saputera)

Table II8 Plastic Packaging Form for Palm Cooking Oil

Source: (Lugito & Saputera)

Packaging Type	Material	Volume (mL)	Weight (gram)	Lifetime
Sachet	BOPP	60	2	Single use
Glass	PET	150	8	Single use
Standing Pouch	Polyolefin	1000	18	Single use
Bottle	PET & PP	2000	86 dan 2	Single use
Jerrycan	HDPE	5000	200	

Table II9 Inventory Database for PET Bottle, Polyolefin Pouch, and BOPP Sachet Packaging

Source: (Lugito & Saputera)

Parameter	Notasi	Bottle	Pouch	Sachet
Refined palm olein	A	1.82 kg	0.91 kg	0.056 kg
Polyethylene terephthalate, granulate, bottle (GLO) market, APOS, U	B	86 g	0	0
Polypropylene, granulate (GLO) market, APOS, U	C	2 g	18 g	2 g
Transport, freight, lorry 16-32 metric ton, EUROS (RoW) APOS, U	D	0.2 tkm	0.1 tkm	0.006 tkm
Extrusion of plastic sheets and thermoforming, inline (GLO) APOS, U	E	88 g	18 g	2 g

Jakarta, as the capital of the country with most of the population, used as a representative case study (Lugito & Saputera). With the assumption that the packaged palm cooking oil is distributed using a freight lorry 16-32t, with an average distribution distance 100 km, the global warming potentials that come from palm oil packaging and distributions are 3.75, 1.95, and 2.78 kg CO_2 per 100 kg CPO for bottle, pouch, and sachet, respectively. CO_2 emissions, as shown in Figure II22, come from refined palm olein (19-36.5%), plastic resources (34.3-54.5%), transport (7.4-14%), and electrical energy (15.3-19.9%).

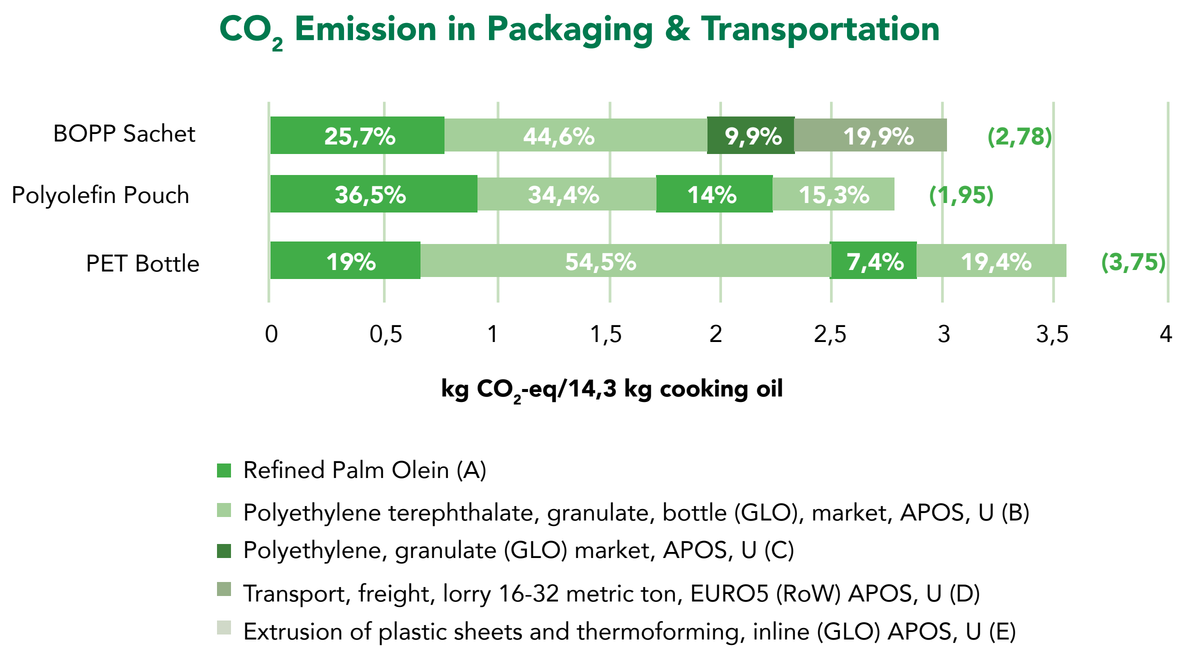


Figure II22 Analysis of Package Cooking Oil with (top) and without (bottom) LULUC

2.3.3.2 Resource Efficiency

The packaging process is one of the areas in which circularity can contribute significantly to reducing the environmental impacts from palm cooking oil industry (ILO, 2023). Indonesia is the biggest consumer of palm cooking oil where the consumption per capita keeps increasing steadily over the past five years (Kompas, 2022). The Ministry of Trade estimates that around 26 per cent of the domestically traded cooking palm oil are packaged (Media Indonesia, 2022). In general, plastic (such as PVC, PET, PP, or PE) is the most common material for cooking oil packaging. Without mitigation and adaptation measures, this can pose environmental risk from plastic waste since plastics constitute as 18,9 per cent of total waste in Indonesia in 2022 (National Waste Management Information System, n.d.) and mostly comes from household, including the palm oil packaging.

To tackle the issues, companies are trying to adopt certain strategies to reduce the environmental risk, one of them through circularity. For example, PT SMART Tbk (member of GAR groups) have been conducting sustainable packaging research with their Downstream R&D department. They continuously innovate in redesigning their packaging to reduce raw material and optimize distribution volume (PT. SMART Tbk, 2017). Currently, their R&D focus is on improving recyclability of packaging materials, especially for pouches (Golden Agri, 2021).

Some companies introduced the circular strategy as part of their sustainability program. PT Indoagri (part of Indofood group) stated in their sustainability report that they are actively engaging their supplier to use a completely recyclable packaging, fully adhering to the Indonesian policy on Extended Producer Responsibility and are planning to phase out bagged oil (Indofood Agri Resources Ltd, 2021). Another company is implementing circularity for packaging in their operational strategy; BKP Group, had switched their bottle packaging into recyclable PET plastic and planning to use recycled material for their palm cooking oil product, supporting waste management program in collaboration with recycling company, and supporting community-based waste collectors (Beritasatu, 2022).

2.3.3.3 Green Jobs

Figure II23 summarizes the relation between circular strategies and how it can affect jobs on the identified circular initiatives in packaging value chain (ILO, 2023). On the other hand, the green jobs opportunity from circularity in the packaging value chain of cooking palm oil can be shown in figure below.

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Packaging green jobs' opportunity mapping

Initiatives	Circular Jobs	Work decency likeliness	Job impact type	Shade of green
Reduce (R2) Innovative packaging • Packaging redesign (to improve efficiency and reduce material usage) • Use of recyclable material (PET plastic)	• Material design • Product design and production • Recycled material supply chain management	Above minimum national standard	Job transformation	Dark

Source: International Labor Organization

Legend: High Low

Figure II23 Packaging Green Jobs' Opportunity Mapping

Source: (ILO, 2023)

Packaging jobs' changing through circular strategies

Initiatives	Innovation	Incurred circular process	Changes in current function	Establishment of new function
Reduce (R2) Innovative packaging • Packaging redesign (to improve efficiency and reduce material usage) • Use of recyclable material (PET plastic)	Product design	• Material design • Product design and Production • Recycled material supply chain management	• R&D[1] • Supply chain management[1] • Packaging production[2]	

Source: International Labor Organization

Legend: (1) Direct enabling jobs, (2) Direct core jobs

Figure II24 Packaging Jobs' Changing Through Circular Strategies

Source: (ILO, 2023)

2.3.3.4 Fiscal and Non-Fiscal Stimulus

The application of circular economy can also be applied to palm oil-based food and beverage packaging (Center of Reform on Economics, 2023). The form of packaging for these products can adopt a variety of present initiatives within the industry including the removal of unrecyclable plastics, packaging innovation, in-store retailer schemes, and label modifications (Gong, Putnam, You, & Zhao, 2020). However, the adoption of greater biodegradable packaging, is still under challenges since "the power of bioscience, using renewable biological resources to replace fossil resources in innovative products, processes and services have not yet been achieved" (Beltran, Tjahjono, Bogush, Juliao, & Texeira, 2021). Therefore, the collaboration among industries as an essential enabler to promote its implementation should be supported by infrastructure to support the production of plastics in the CE and the technical implications of packaging (Gong, Putnam, You, & Zhao, 2020).

In a few Indonesian cities, several groups backed by local governments have created initiatives to recycle waste, including plastic (Center of Reform on Economics, 2023). Unfortunately, the packaging used for cooking oil, for example, still contains plastic that cannot be processed or accepted at the recycling plant.

In addition, the public requires additional information regarding the appropriate processing of waste cooking oil plastic. Due to a lack of processing, cooking oil plastics are typically discarded in landfills, which exacerbates the waste problem. Therefore, someone must acquire and recycle used cooking oil plastic waste to reduce the amount of waste in landfills. Companies utilizing plastic packaging should be compelled to manage non-recyclable waste. Alternatively, palm oil producers are obliged to use more eco-friendly packaging that can be recycled. Therefore, to support this strategy, the reward and punishment system must be modified to function as an incentive and disincentive for business actors.

Since linear items used in food and beverage packaging, including the palm oil products and their derivatives, tend to be less expensive due to their abundance, it is important to incentivize companies to implement circular economy principles in the packaging processes (Center of Reform on Economics, 2023). Accordingly, the government may, for instance, offer financial incentives, such as reducing VAT and/or corporate income tax, for business that develop and utilize biodegradable packaging to businesses that develop and utilize circular economy-compliant packaging. This may include utilizing biodegradable packaging, reducing the size and thickness of plastic packaging, using biodegradable water-activated tape, utilizing certified recycled paper and uncoated paper, removing the polypropylene label for simple recycling, discontinuing the use of colorful packaging, and utilizing mono-materials to reduce the difficulty level of recycling.

On the other hand, the government can discourage corporations from using fossil fuel-based packaging by expanding the scope of plastic taxes (Center of Reform on Economics, 2023). For example, they could extend the tax to cover not just plastic bags, but also packaging for various consumer goods. In 2019, the government drafted a regulation on excisable goods in the form of plastic bags, but it has not been implemented yet. According to the draft regulation, shopping bags made of plastic used to carry commercial goods are considered subject to excise duty. Table II-10 shows implementation, obstacles, and incentives of circular economy in the palm oil-based products packaging stage.

Table II10 Implementation, obstacles and incentives of circular economy in the palm oil-based products packaging state

Source: (Center of Reform on Economics, 2023)

Implementation	Traits/Obstacles	Incentives	Enabling Condition
Initiatives that can be adopted include the removal of unrecyclable plastics, packaging innovation, in-store retail schemes, and label modification (Gong, Putnam, You, & Zhao, 2020)	The power of bioscience to replace fossil resource in innovative products, processes, and services have not yet been achieved (Beltran, Tjahjono, Bogush, Juliao, & Texeira, 2021)	Reduce VAT and/ or corporate income tax for businesses that develop and utilize biodegradable packaging.	The shared understanding about the urgency of the circular economy among stakeholders, including consumers, to run the program.
	Plastics packaging used for cooking oil is hard to recycle and ends up in landfills.	Broaden the scope of plastic excise tax, not only on plastic bags but also on plastic-based packaging for various customer goods.	The availability of guidelines to define biodegradable packaging and to outline the procedures for obtaining tax reductions.

2.3.4 Post Consumption Value Chain

The increased use of recyclable packaging of palm cooking oil can benefit the recycling industry (ILO, 2023). Estimates shows that current recycling rate in Indonesia is only at 7 per cent with 75 per cent of them are being PET plastics. With the limited supply from domestic waste collection and the virgin plastic production, domestic plastic manufacturers need to import around 750.000 tons of material annually (Republika, 2023), signaling significant opportunity for plastic recycling industry. This industry is dominated by small-medium players, accounting for around 1,590 businesses that employed approximately 177,000 people in 2019 (Putri, Fujimori, & Takaoka, 2018). The formal sector consists of municipal agencies and formal businesses such as waste banks and waste management start-ups, whereas the informal sector consists of individuals, groups, and small businesses engaging in activities that are not registered and are not formally regulated. In an interview with PET plastic recycling company, it is said that the industry began to grow rapidly since 2017, one of them due to the increased campaign on environmental danger from plastic waste. There were numbers of waste management start-ups established during this period, as well as community-based waste collection initiatives.

In general, the industry ecology of plastic recycling in Indonesia is divided into three lines: upstream (waste collectors), midstream (waste aggregator and intermediary), and downstream (plastic recycling industry) as shown in Figure II-25. The upstream and midstream process are still mostly contributed by informal economy, namely the waste picker and individual business waste collectors (from small to big scale aggregators), which depend mostly on manual labor. Study found that currently, domestic waste collection for the plastic recycling industry is still contributed mostly by these actors (Darus, et. al., 2020). The rise of the waste management start-ups shows a modernization in business model where technology and social innovations are introduced into the business process through social campaign to trigger behavioral change, innovative business models, use of IT-based system and applications for tracking and collection, as well as mechanization (mostly simple technology) for processing. Most of the start-ups focus on certain chains and processes, but some of them operate an integrated business. The conventional recycling companies are mostly plastic manufacturing companies. They process plastics from various sources including unprocessed plastic waste, recycled plastics from midstream companies (usually in the form of flakes or bulk), or virgin plastics from chemical companies. The most common technology used for recycling is the mechanical process, especially for small to medium companies (USAID, 2022).

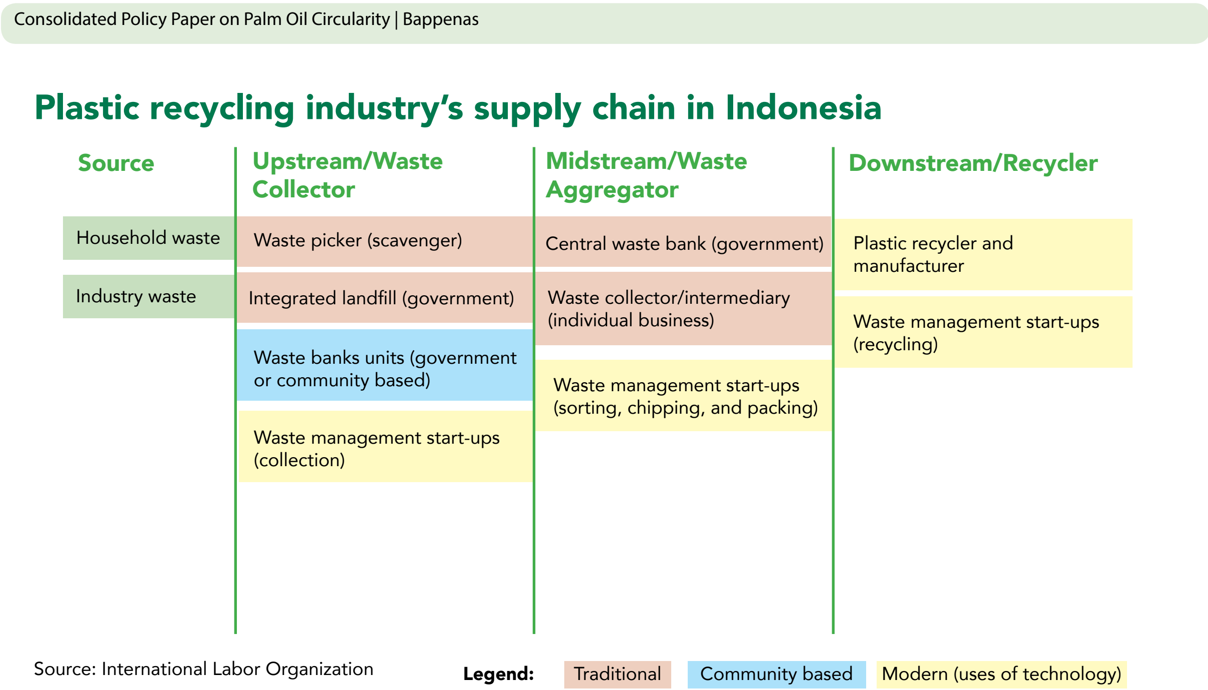

Figure II25 Plastic Recycling Industry's Supply Chain in Indonesia

Source: (ILO, 2023)

The plastic recycling industry is currently hindered by the limited qualified supply in the upstream, as well as the limitation of available technology in the downstream (ILO, 2023). The lack of proper waste segregation especially from the household level has made the input quality sub-standard where plastic waste is often highly contaminated and requires extra efforts for processing. Contamination leads to an unstable supply of recycled plastic waste and is identified as the main obstacle of the waste management companies' sustainability, based on the interview with plastic recycling start-ups. On the downstream stage, most of the recycling companies that currently operating in Indonesia only process rigid plastics (mostly PET, PP, and HDPE) (USAID, 2022). Given the condition, promoting the palm cooking oil industry to switch the packaging into PET plastic can contribute to the growth of recycling industry. However, this needs to be accompanied with support in enabling behavioral changes or mechanism which can improve the waste quality from the source as well as collection management.

Another opportunity in the post-consumption chain comes from the recycling of used cooking oil (UCO) for biodiesel (ILO, 2023). **Figure II26** shows palm used cooking oil supply chain in Indonesia. Recent study by National Team for the Acceleration of Poverty Reduction (TNP2K) and Traction Energy shows that in 2019, only 18,5 per cent of the total UCO from domestic consumption were collected. From this amount, around 75 per cent of them were recycled for consumption, 17 per cent were domestically converted into biodiesel and other manufacturing product, and the remainders were exported mostly for biodiesel (Asia, 2020). Like plastic recycling, the challenges for converting UCO for biodiesel come from the collection and the manufacturing process. In the collection stage, the absence of collection mechanism of UCO was identified as the cause of low conversion rate (MEMR, 2020). On the manufacturing side, technology limitation also hampers the capacity of domestic biodiesel producers (MEMR, 2020).

Source: International Labor Organization

Figure II26 Palm Used Cooking Oil Supply Chain in Indonesia

Source: (ILO, 2023)

Although the rate of UCO collection is still below the optimum capacity, the awareness of its' economic value is getting traction (ILO, 2023). Currently, various actors are involved in the collection process; spanning from formal to informal sector, and vary by organization's type, size, and characteristics. The formal sectors are also more diverse; there are government entities, enterprises, cooperatives, and social foundations. Nevertheless, there are also informal actors such as the individual business and community-based groups which often partner with formal actors. In general, the transaction modes of these UCO collections are executed via trade, waste bank, and charity (Syahni, 2021).

The circular strategy in the upstream chain typically introduces social innovation that enables organized collection mechanism (ILO, 2023). Examples of this strategy include community-based activism through certain cause such as environment, economy, and religious campaign (e.g. the *Tersenyum Program* from *Rumah Sosial Kutub* that use environmental and charity and religious-campaign and KSM Tarakan Timur that use environmental and local economy campaign).

This is often accompanied with innovative partnership between the organization with local government (such as villages and municipalities) for example the *Tersenyum Program* is supported by Jakarta Provincial Government and Rumah Harum Waste Bank is supported by Depok Municipality, or privates and development partners for example the KSM Tarakan Timur was supported initially by Pertamina Group's CSR just like *Tersenyum Program* was supported by PLN's CSR, while PT Bali Hijau Lestari was established as a partnership between the Government City of Denpasar, CARITAS Switzerland, Foundation Myclimate, and Kuoni. Through this business model, the circular strategy had allowed economic value and job creation, albeit on a small scale. Although some of the jobs created by the circularity are not in full employment, the initiatives have contributed to formalization of the economy by encouraging new formal entities establishment such as village owned companies/BUMDES, cooperatives, and small businesses. There are also examples of technological innovation within this chain such as those introduced by waste management start-ups that incorporate IT based system to help collection process for household and industry waste – including UCO, where these entities act mostly as the platform provider, facilitator, and collector (e.g. Rekosistem and Jangjo).

Limited access to local producers and the premium price is the key reasons motivating UCO export (ILO, 2023). An interview with a UCO collector (*Rumah Sosial Kutub*) document that the organization does not have access to local biodiesel producers and therefore depends fully on export. While profitable, this makes their business model vulnerable, with trade regulation changes such as export bans. At the other end, most of the well documented biodiesel converters operate under integrated business models (i.e., from collection to conversion), for example PT Bali Hijau Lestari Biodiesel and PT Bali *Jelantah*. Often, they also create industry symbiosis in which they initiate strategic partnership with relevant entities that have the access to suppliers (e.g., cooperation with BUMDES and F&B industries), transportation services (e.g., strategic partnership with online transportation platform), and buyers (e.g., sale and purchase agreement with the industry). On top of this business model, enterprise-led initiatives are also emerging where most of the companies use the recycled product for their own need (e.g., Cargill, Adaro, Danone-Aqua, and Unilever Indonesia) (Asia, 2020).

However, some companies decided to reduce the use of the UCO-based biodiesel due to needs and cost consideration. One of the possible causes of this trend is due to price competition in which the rising UCO market for biodiesel, including for export, has made the domestic conversion cost higher.

2.3.4.1 Waste and CO2 Reduction

The consumption of vegetable cooking oil can be considered carbon neutral, meaning the CO_2 released when it is burned is the same as the CO_2 taken by the plant to grow (Lugito & Saputera). Indonesian cooking oil consumption per capita in 2022 is projected to approximately be 6 MMt (6.6 MM^3). Through purification, refinement, and transesterification, 1.64 MM^3/year used in cooking oils could produce 1.23 MM^3 (35% of yearly biodiesel demand), reduce 6 MT GHG, save 1.16 MT CPO/year, and save 321 thousand ha of forestation. Used cooking oil also could cause a lot of environmental issues: (1) it hardens and infiltrates into a local sewers, water, and waste management facilities when poured down the drain, and (2) it affects our food supply when tossed in the trash or carelessly littered in the dirt or grass outside.

In the production of palm cooking oil (RPO olein), the impacts are mainly associated with upstream activities at the palm oil plantation and the palm oil mill, packaging and distributions are found to have minor impacts on the environment(Lugito & Saputera). The main contributor to the fossil fuels category is production and use of fertilizers for the cultivation of palm oil, with minor inputs from the refining and fractionation processes through the transport of raw and waste material and distribution of products, as well as the use of boiler fuel.

2.3.4.2 Resource Efficiency

UNIDO does not address resource efficiency aspects of post consumption value chains.

2.3.4.3 Green Jobs

Broader opportunity for job creation and substitution is available in the post consumption chain. The circular strategies within this stage employ a wide range of socio-technical innovations, mostly revolving around PET Plastic and UCO recycling (ILO, 2023).

The range of applied technology also varies greatly; the recycling processes use simple technology and mechanical and/or chemical processes, but the use of ICT based technology is increasing with the rise of waste management start-ups. This technology is used mostly for facilitating waste collection, monitoring supply chain, and facilitating behavioral change. While the sector is still heavily dependent to the informal economy especially for waste collection, the increasing recycling trend had also induced the establishment of new business entities in the form of enterprises, cooperatives, individual business, and other legally recognized business entities. This trend in turn promotes formalization in the sector, albeit mostly on a small scale due to the limited capacity. This creates employment, which in some cases shows job substitution where the informal workers fill the occupation in the newly established entities.

Nevertheless, the sector still faces large challenges in achieving decent work (ILO, 2023). Due to their limited capacity, waste management and recycling start-ups tend to keep the labor cost low by minimizing permanent employers while maximizing the use of temporary employment contract for their supporting function (including for core function such as system development) and part-time workers for their non-managerial operational workers (sometimes paid by piecemeal rate). The permanent and temporary/contract workers mostly have remuneration that meets the minimum wages regulation and access to social protection (both BPJS TK and BPJS Kesehatan). They also have access to training especially when the enterprise is starting to implement new technology or expand the business. However, labor union and collective bargaining are very rare. In contrast, the part-time workers rarely enjoy these rights at work; although companies say that their wages are based on the regulation, the prevalence of part time and casual work mean workers rarely achieving subsistence wages. Figure II-27 and Figure II-28 consecutively shows green jobs' opportunity mapping and jobs' changing through circular strategies in post consumption value chain. On the other hand, Figure II-29 summarizes the related decent work challenges given the characteristic of post consumption chain that needs to be addressed when designing a just circular transition as well as the skill requirement, categorized based on the type of direct jobs (core and enabling).

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Post consumption green jobs's opportunity mapping

Initiatives	Circular Jobs	Work decency likeliness	Job impact type	Shade of green
Recycling (R8) Recycling PET packaging	• Waste management • Waste collecting • Plastic recycling • Supplay Chain Management	Meeting minimum national standard (only for formal economy)	Job transformation, creation or substitution	Light
Repurpose (R7) Converting UCO to biodiesel	• Waste management • Waste collecting • Biodiesel manufacturer • Sales and Marketing	Meeting minimum national standard (only for formal economy)	Job transformation, creation or substitution	Light

Source: International Labor Organization

Legend: High Low

Figure II27 Post Consumption Green Jobs' Opportunity Mapping

Source: (ILO, 2023)

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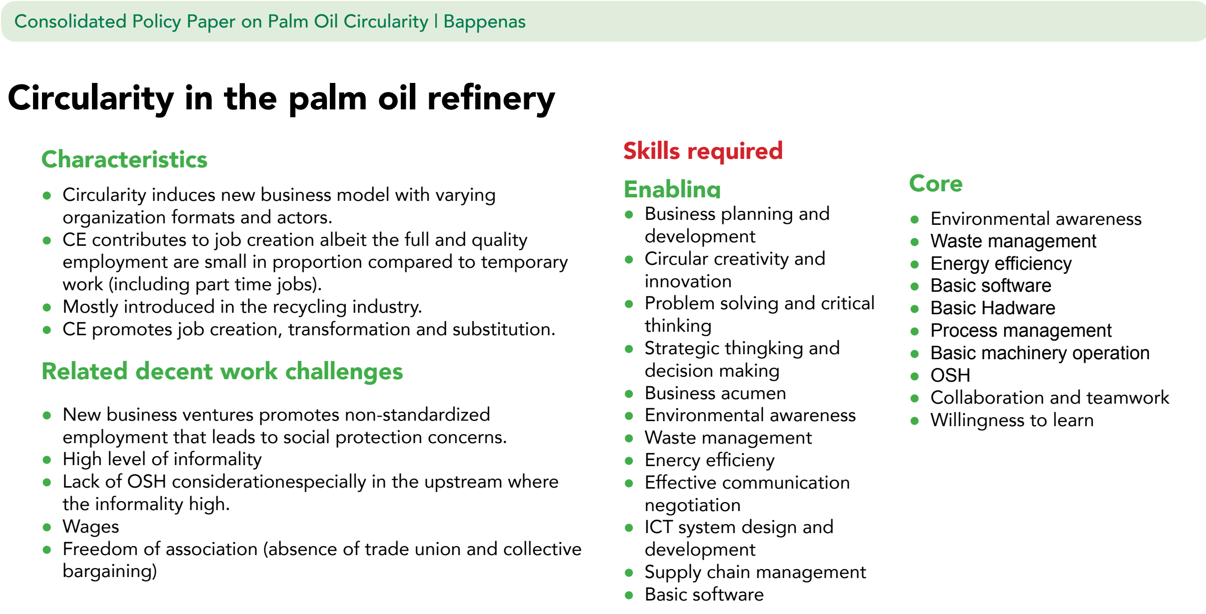
Post consumption job's changing through circular strategies

Initiatives	Innovation	Incurred circular process	Changes in current function	Establishment of new function
Reduce (R2) Recycing PET packaging	• Core technology • Product design • Socio-institution	• Waste management • Waste recollecting • Plastic recycling • Supply chain management	• R&D[1] • waste picker/collector[2] • waste agregator[2] • Waste management[2] • Plastic recycling[2]	• Business development and partnership[1] • IT system development[1] • Plastic use and disposal educator/campaigner[2] • Plastic supply chain management
Repurpose (R7) Converting UCO to biodiesel	• Core technology • Product design • Socio-institution	• Waste management • Waste collecting • Biodiesel manufacturer • Sales and marketing	• R&D[1] • waste picker/collector[2] • waste agregator[2] • Waste management[2] • Plastic recycling[2]	• Business development and partnership[1] • IT system development[1] • UCO disposal educator/campainer[2] • UCO supply chain management[2]

Source: International Labor Organization **Legend:** (1) Direct enabling jobs, (2) Direct core jobs

Figure II28 Post Consumption Jobs' Changing Through Circular Strategies

Source: (ILO, 2023)

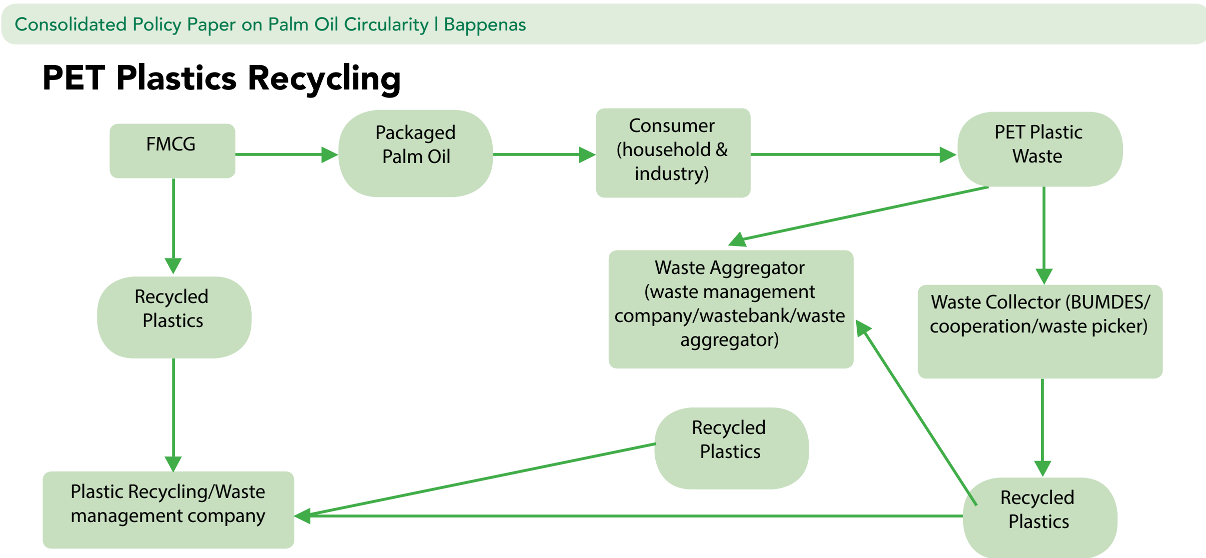


Source: International Labor Organization

Figure II29 Circularity in the Palm Oil Post Consumption

Source: (ILO, 2023)

The growing PET Plastic and UCO recycling industry promotes job creation and new economic activity and entities, by inducing a pattern of industrial symbiosis (ILO, 2023). Although not all the activities show the complete pattern, the new business models often incorporate social innovations in which they promote sharing economy and other inter-organizational collaborations. Figure II-30 and Figure II-31 capture the example of symbiosis network in the palm cooking oil waste recycling in which various businesses form a network in a supply chain process that connects the previously independent sectors into one industry ecosystem.



Source: International Labor Organization

Figure II30 Industrial Symbiosis Network in the PET Plastics Recycling

Source: (ILO, 2023)

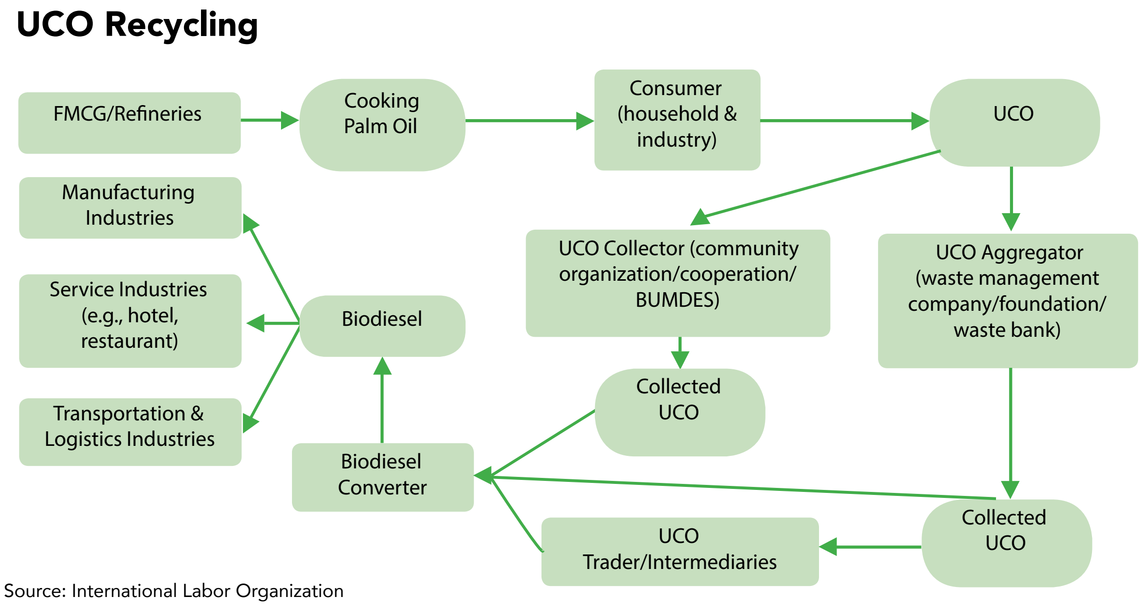


Figure II31 Industrial Symbiosis Network in the UCO Recycling

Source: (ILO, 2023)

Geographical area is the common factor that drives this symbiosis (ILO, 2023). The absence of organized collecting mechanism both for PET plastic and UCO motivates the recycling industry to form location-based cooperation which in some cases, it also promotes the establishment of new ventures that contribute to the local economic development (e.g., BUMDES or Cooperative for waste collection).

Cooperation with industrial areas is also another option pursued by the recycling companies, especially in the up and mid-stream process. In some cases, Government support in the form of regulation and policy measures that enable this recycling company to operate in certain areas (sometimes exclusively) are also critical factors that accelerate the adoption of circular processes. Industry support in providing capital and access to skill to the recycling company, especially in the initial stages, were determining success factors in several cases. This cooperation between various factors that are growing in the post consumption chain contributes not only to job creation.

2.3.4.4 Fiscal and Non-Fiscal Stimulus

The use of waste cooking oil (WCO), including palm oil-based products, used as a sustainable feedstock for biofuel production is another implementation of a circular economy in the palm oil industry (Center of Reform on Economics, 2023). WCO has significant potential for advanced transportation fuel production for the ground and aviation industries. Hence, it has become a solution to increase the value of biowastes through energy recovery while also overcoming the disposal issue. Therefore, advancements in fuel manufacturing technology and associated policies would accelerate the adoption of sustainable WCO biofuels (Goh, et al., 2020).

In the context of Indonesia, WCO has been utilized but still on a limited scale. One of the organizations that already manages WCO is Bandung City Main Waste Bank (Center of Reform on Economics, 2023). This organization receives WCO from society because buyers or off takers for that product are available, remembering the Waste Bank business model is "trading the waste" to reduce waste amount and extend its lifespan. The primary customer of WCO comes from AKAR (Asosiasi Kafe Restoran Jawa Barat/West Java Restaurant Cafe Association), for the export of biodiesel material to Eruope. In addition to AKAR, Bandung City Waste Bank also allows individual off stakers to purchase WCO. Although there is a significant risk of WCO being misused for consumption by certain parties, Waste Banks do not have strict procedures for choosing WCO buyers. Thus, when WCO management is implemented on a large scale in the future, the government can certify or issue a legal permit to specific organizations to prevent any potential abuse.

Besides the condition, Bandung City Main Waste Bank also has some challenges to increase the recycling rate due to: (1) lack of capacity for waste-receiving units at the household level, (2) lack of socialization, facilitation, and assistance related to waste banks in the community, (3) insufficient volume of waste to be absorbed by advanced waste processing companies which leads to landfill (open dumping), as well as (4) lack of waste vehicles, so it is not optimal to transport it.

The government could provide subsidies to biofuel companies that manufacture their products using recycled materials, such as waste cooking oil, to reduce their production costs and achieve competitive pricing with non-biofuel fuels (Center of Reform on Economics, 2023). Providing subsidies to waste cooking oil (WCO)-based biofuel companies to lower their production costs and boost their price competitiveness with non-biofuel fuels to circular-based products is also important to encourage customers to shift to the product-based circular process from product-based linear and hence could stimulate more private sector to involve in this business. Moreover, the government could include WCO-based biofuel in the VAT-free list to stimulate demand for biofuels. In addition, the government could also regulate the maximum amount of waste that food and beverage companies, including palm oil derivative companies, can dispose of in landfills. As a result, the government can impose fines on businesses that dispose of waste more than a predetermined quota by multiplying the amount disposed of by a government-established price. This method will encourage companies to reduce or treat their garbage, including recycling it for energy production. As an alternative, businesses that reduce or recycle their waste and comply with government regulations may be eligible for incentives such as tax income deduction. The government has urged businesses to manage their waste in accordance with Law No. 18 of 2008 regarding Waste Management, which states in Article 1 that "producers are expected to manage packaging and/or products that cannot or are difficult to disintegrate by natural processes." However, because the regulation is optional, businesses tend to disregard it. Hence, with more specific and binding laws, it is envisaged that companies, particularly those in the food and beverage industry, as well as palm oil industries and their derivatives, will be enhanced to implement a circular economy for their waste. Table II-11 shows implementation, obstacles and incentives of circular economy in the palm oil-based consumption and disposal stage.

Table II11 Implementation, obstacles and incentives of circular economy in the palm oil-based consumption and disposal stage

Source: (Center of Reform on Economics, 2023)

<table>
<tr><th>Implementation</th><th>Traits/Obstacles</th><th>Incentives</th><th>Enabling Condition</th></tr>
<tr><td rowspan="2">Use waste cooking oil (WCO) as a sustainable feedstock for biofuel production.</td><td rowspan="2">WCO utilized in very limited scales due to:
1. Lack of capacity for waste-receiving units at the household level.
2. Lack of socialization, facilitation, and assistance related to waste banks in the community.
3. Insufficient volume of waste to be absorbed by advanced waste processing companies.
4. Lack of waste vehicles.</td><td>Provide subsidies to WCO-based biofuel companies to lower their production costs and boost their price competitiveness with non-biofuel fuels.</td><td>The shared understanding about the urgency of the circular economy among relevant stakeholders, including consumers, to run the program.</td></tr>
<tr><td>Include WCO-based biofuel in the VAT-free list to stimulate demand for biofuels.</td><td>Awareness of WCO-based biofuel companies, both the existing and the newcomers’ companies, regarding the availability of government subsidy programs.</td></tr>
<tr><td rowspan="2">In Indonesia, the primary customer of WCO (West Java Restaurant Café Association/AKAR) exports them as biodiesel material to Europe.</td><td rowspan="2">No legal procedures about WCO management, thus it is risky to be misused for consumption.</td><td rowspan="2">Regulate maximum amount of waste that can be disposed of in landfills & gives incentives such as tax income deduction for businesses who comply with it.</td><td>Technical guidelines define WCO-based biofuels products and set permitted amount of waste.</td></tr>
<tr><td>Consumer awareness regarding the benefit of biofuels.</td></tr>
</table>

CHAPTER 3

POLICY RECOMMENDATION

After conducting a thorough calculation and detailed analysis in the preceding Section 2, we have finally synthesized a set of recommended actions for the palm oil industry value chain. These suggestions are derived from a meticulous examination of the sequential processes involved in the production and distribution of palm oil industry. By leveraging our insights, we propose strategic steps that can be undertaken to enhance efficiency, sustainability, and overall effectiveness within the palm oil industry. These recommendations aim to contribute to the responsible management of the value chain, addressing key challenges and fostering positive outcomes for both industry and the broader ecosystem.

Table III1 Technical recommendation on each palm oil industry value chain stage & process

Value Chain	Stage/Process	Recommendation
Plantation	Land Preparation	a. Plant trees on the most suitable land that can support palm oil's growth naturally
	Pre-Nursery	b. Provide access & subsidize high-quality (superior) palm oil seed to increase yields and productivity
	Nursery	
	Seedlings Selection	
	Actual Planting	c. Encourage agroforestry & silvopasture that can naturally supply essential elements to reduce palm oil trees' needs for fertilizer Example: Agroforestry = integrate legume cover crops with palm oil trees Silvopasture = integrate cattle with palm oil trees (POCI)
	Monitoring & Treatment	d. Enable precise fertilizer application and prevent excessive fertilization through advanced fertilizer technology such as FOSS NIR DA2500
		e. Substitute chemical pesticides with natural predators
	Harvesting	f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer
Milling	Mill development	g. Decentralize milling location to reduce transportation costs
		h. Develop SPOT technology to streamline milling & refinery processes and reduce "liquid"-based waste
	FFB Sterilization	i. Utilize highly-precise technology in controlling fresh fruit bunches (FFB)'s quality that goes into the milling process
	FFB Stripping	j. Substitute chemical substances from fresh fruit bunches (FFB) stripping process with clay bath technology
	Oil extraction	k. Implement semi-digital or digitalization to accurately identify issues within production processes
		l. Utilize advance technology (Such as FOSS NIR DA1650 analyzer) to detect oil loss at every production stage

Value Chain	Stage/Process	Recommendation
Milling	Waste treatment	**POME** m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment
		n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production
		o. Develop Bio-Compressed Natural Gas (Bio-CNG) plant to produce biomethane for palm oil plantation trucks' fuel
		EFB p. Utilize empty fruit bunches (EFB)-based fertilizer for soil health treatment
		Fiber & Shell (Biomass) q. Utilize biomass produced in the palm oil sector, such as shells and fiber for palm oil plantation trucks & boiler

Every recommendation outlined in our analysis is also plotted by a well-defined set of policy guidelines, specifying the necessary regulatory framework to support its implementation. Additionally, each recommendation comes with a clear target contribution, outlining the expected impact on key performance indicators or sustainability metrics. We have also established a recommended period for implementation, taking into consideration factors such as feasibility, urgency, and potential ripple effects throughout the value chain. Furthermore, we have identified the stakeholders who play crucial roles in the successful execution of these recommendations, ensuring a collaborative and inclusive approach to their implementation. This comprehensive framework is designed to provide a structured and actionable plan for stakeholders across the palm oil value chain.

Table III2 Synthesized technical & policy recommendation

Technical Recommendation					
Value Chain(s)	Target Contribution	Policy Recommendation	Actions	Period	Stakeholders
Plantation	Reduction of land use & land-use change (LULUC) in areas with high carbon content, such as primary forests and peatlands	Develop standardized guidelines for mapping and implementation of best practice methods to ensure effective soil and water conservation in each region	a. Plant trees on the most suitable land that can support palm oil's growth naturally	Long	PTPN, Private Companies, and Smallholders; Ministry of Environment and Forestry; Regional Government
	Low Carbon and Intensification > Water recovery and carbon reduction.	Ensure equitable access to high-quality palm oil seeds by instituting a policy that allows the government to provide subsidies when necessary, promoting the cultivation of improved varieties and enhancing overall productivity in the palm oil industry.	b. Provide access & subsidize high-quality (superior) palm oil seed to increase yields and productivity	Short	Ministry of Agriculture; Palm Oil Plantation Fund Management Agency; Regional Government; Palm Oil Grower Association
		Enforce comprehensive agricultural practices within palm oil plantations, including the adoption of precision agriculture for fertilization, the substitution of chemical pesticides with predators, the utilization of biological agents for natural nutrient supply, incorporating Oil Palm Front (OPF) for nutrient recycling and soil conservation, and promoting Palm Oil Cattle Integration (POCI) to enhance sustainable and integrated land management practices.	c. Enable precise fertilizer application and prevent excessive fertilization through advanced fertilizer technology such as FOSS NIR DA2500	Long	Industrial Plantation players; Palm Oil Grower Association; Ministry of Environment and Forestry; Ministry of Industry; Palm Oil Plantation Fund Management Agency; Education institutions; Research and Development Agencies
			d. Substitute chemical pesticides with natural predators	Long	
			e. Encourage agroforestry & silvopasture that can naturally supply essential elements to reduce palm oil trees' needs for fertilizer	Mid	

Technical Recommendation					
Value Chain(s)	Target Contribution	Policy Recommendation	Actions	Period	Stakeholders
	Waste Management and Utilization	Introduce a holistic framework aimed at transforming Oil Palm Front (OPF) into handicrafts to enhance communities' livelihoods, alongside the establishment of Miniature Sustainable Plantations, pilot mills, and refineries, strategically designed for tourism and investor funding support.	f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer	Short	Ministry of Small and Medium Enterprises and Cooperatives; Ministry of Tourism and Creative Economy; CSR company; Smallholders association
Milling		Disseminate an integrated and sustainable agricultural strategy within the palm oil sector, incorporating precision agriculture practices, substitution of chemical pesticides with natural predators, utilization of diverse biological agents to naturally supply essential elements for plants, incorporation of Oil Palm Front (OPF) to enhance nutrient recycling and soil conservation, and promotion of Palm Oil Cattle Integration (POCI) to foster sustainable land management practices.	m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment	Short	Industrial players; Ministry of Environment and Forestry; Palm Oil Plantation Fund Management Agency; Education institutions; Research and Development Agencies;
			n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production & fertilizer		
			o. Develop Bio-Compressed Natural Gas (Bio-CNG) plant to produce biomethane for palm oil plantation trucks' fuel		
			p. Utilize empty fruit bunches (EFB)-based fertilizer for soil health treatment		
			q. Utilize biomass produced in the palm oil sector, such as shells and fiber for palm oil plantation trucks & boiler		

Technical Recommendation					
Value Chain(s)	Target Contribution	Policy Recommendation	Actions	Period	Stakeholders
	Milling & Refinery Process Intensification	Institute a comprehensive technological advancement strategy in the palm oil industry, including the development and utilization of high-precision assessment technology, the substitution of chemical substances, and the digitalization.	i. Utilize highly-precise technology in controlling fresh fruit bunches (FFB)'s quality that goes into the milling process	Long	Business association (GAPKI); Ministry of Industry; Education institutions; Research and Development Agencies; Palm Oil Plantation Fund Management Agency
			j. Substitute chemical substances from fresh fruit bunches (FFB) stripping process with clay bath technology	Long	
			k. Implement semi-digital or digitalization to accurately identify issues within production processes	Long	
			l. Utilize advance technology (Such as FOSS NIR DA1650 analyzer) to detect oil loss at every production stage	Long	
		Institute a comprehensive approach in mill decentralization strategies and adoption of SPOT (Steamless Palm Oil Technology)	h. Develop Steamless Palm Oil Technology (SPOT) to streamline milling & refinery processes and reduce "liquid"-based waste	Long	Ministry of Industry; Ministry of Environment and Forestry; Palm Oil Plantation Fund Management Agency; Education institutions; Research and Development Agencies; Business association (GAPKI)
			g. Decentralize milling location to reduce transportation costs	Long	

In addition to our technical recommendations, we have incorporated a dual-layered approach that includes both fiscal and non-fiscal (non-technical) recommendations to bolster the feasibility of subsequent actions. The fiscal recommendations encompass financial considerations such as taxation policies that can support the proposed measures. On the other hand, non-fiscal recommendations focus on non-technical aspects, including regulatory frameworks, social engagement strategies, and community involvement initiatives. This multifaceted approach aims to create a holistic environment conducive to the successful implementation of our suggestions. By addressing both the financial and non-financial dimensions, we strive to enhance the overall viability and sustainability of the recommended actions within the palm oil industry value chain.

Table III3 Synthesized non-technical (fiscal/non-fiscal) recommendation

Non-Technical Recommendation				
Incentives/Disincentives		Supported Actions	Period	Stakeholders
Fiscal	Non-Fiscal			
	Provide sufficient subsidies for small and privately owned plantations which have clear legality of land to obtain and renew ISPO certificate	Enhance productivity and competitiveness of oil palm plantations through compliance with ISPO Instruments.	Short	- Key Stakeholders: BPDKS; - Targeted Stakeholders: Smallholder Farmers
	Provide affordable financing schemes for ISPO certification such as through KUR (Business Credit for Micro and Small Enterprises) and UMI (Financing for Ultra Micro Enterprise)		Short	- Key Stakeholders: Financial Services Authority (OJK) and Financial Institutions; - Targeted Stakeholders: Smallholder Farmers
	1) Simplify certification process and provide training and resources to help farmers understand the benefits of ISPO certification and how to obtain it 2) Fund ISPO certification fee assistance for smallholders through APBN, APBD and ohter sources as per relevant laws and regulations 3) Provide counseling related to CE applications to farmers		N/A	- Key Stakeholders: Ministry of Agriculture; - Targeted Stakeholders: Smallholder Farmers
Reduce export excise tax for companies that purchase ISPO-based products at higher prices to establish price differential between ISPO and non-ISPO-certified products.			N/A	- Key Stakeholders: Ministry of Finance; - Targeted Stakeholders: Companies & Farmers

Non-Technical Recommendation				
Incentives/Disincentives		Supported Actions	Period	Stakeholders
Fiscal	Non-Fiscal			
Reduce corporate income tax and/or reduce export excise tax for companies using circular products, such as palm bunch ash and POME-based fertilizers in the plantation.		f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production o. Develop Bio-Compressed Natural Gas (Bio-CNG) plant to produce biomethane for palm oil plantation trucks' fuel p. Utilize empty fruit bunches (EFB)-based fertilizer for soil health treatment q. Utilize biomass produced in the palm oil sector, such as shells and fiber for palm oil plantation trucks & boiler	N/A	- Key Stakeholders: Ministry of Finance; - Targeted Stakeholders: Companies - Key Stakeholders: Ministry of Finance; - Targeted Stakeholders: Manufacturing companies, especially small and medium scale industry
Provide incentives for companies to build POME treatment installation, such as import duty free for POME installation capital goods (e.g. Boiler) and/or tax allowance			N/A	- Key Stakeholders: Ministry of Finance; - Targeted Stakeholders: Manufacturing companies, especially small and medium scale industry

Non-Technical Recommendation				
Incentives/Disincentives		Supported Actions	Period	Stakeholders
Fiscal	Non-Fiscal			
	Provide affordable financing schemes for POME treatment installation such as through KUR and UMI	m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production o. Develop Bio-Compressed Natural Gas (Bio-CNG) plant to produce biomethane for palm oil plantation trucks' fuel	N/A	- Key Stakeholders: Financial Services Authority (OJK) and Financial institutions ; - Targeted Stakeholders: Small and medium scale manufacturing companies

Non-Technical Recommendation				
Incentives/Disincentives		Supported Actions	Period	Stakeholders
Fiscal	Non-Fiscal			
	Provide funding for RnD in palm oil based circular economy such as POME treatment and biodiesel production at a lower cost	f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production o. Develop Bio-Compressed Natural Gas (Bio-CNG) plant to produce biomethane for palm oil plantation trucks' fuel p. Utilize empty fruit bunches (EFB)-based fertilizer for soil health treatment q. Utilize biomass produced in the palm oil sector, such as shells and fiber for palm oil plantation trucks & boiler	N/A	- Key Stakeholders: BPDKS; - Targeted Stakeholders: Manufacturing companies, research, and academic institutions

Non-Technical Recommendation				
Incentives/Disincentives		Supported Actions	Period	Stakeholders
Fiscal	Non-Fiscal			
	Encourage utilization of biomass from POME as an energy input for PLN, with a competitive tariff	n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production	N/A	- Key Stakeholders: Ministry of energy and mineral resources, PLN; - Targeted Stakeholders: Manufacturing companies
Reduce VAT and/or corporate income tax for palm oil industries which adopt repair and reuse practices in their production		m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment p. Utilize EFB-based fertilizer for soil health treatment f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer	N/A	- Key Stakeholders: Ministry of Finance; - Targeted Stakeholders: Manufacturing Companies
	Provide business license issuance mechanism to control wastewater discharges	Adopt best practices in wastewater management and adhere to regulatory compliance requirements.	N/A	- Key Stakeholders: Investment Coordinating Board (BKPM), Ministry of Environment and Forestry, and District Government; - Targeted Stakeholders: Companies

In tandem with our fiscal and non-fiscal recommendations, we advocate for the integration of green jobs as a pivotal element to ensure the availability of resources crucial for the successful implementation of technical recommendations within each segment of the value chain. By incorporating green job initiatives, we aim to not only address environmental concerns but also stimulate economic growth and employment opportunities within the sustainable sector. These green jobs can span various roles, including research and development, conservation, renewable energy, and eco-friendly agriculture practices, aligning with the overarching goal of fostering environmental responsibility. This strategic inclusion of green jobs serves as a catalyst, promoting both ecological sustainability and economic prosperity, thereby reinforcing the foundation for the seamless execution of technical recommendations across the palm oil industry value chain.

Table III4 Green/circular jobs opportunities for sustainable palm oil industry value chain

Strategy	Technical recommendation	Circular Jobs	Work Decency	Job Impact	Shade of Green
Recovery (R9)	q. Utilize biomass produced in the palm oil sector, such as shells and fiber for palm oil plantation trucks & boiler	- Product design - Waste processing - Machinery operation - Trading by-product for bioenergy	Above minimum national standard	Job transformation or creation	Medium
Repurpose (R7)	n. Develop methane capture technology to produce biogas from palm oil mill effluents (POME) for electricity production o. Develop Bio-CNG plant to produce biomethane for palm oil plantation trucks' fuel	- Product design - Waste processing - Machinery operation	Above minimum national standard	Job creation or substitution	Medium
Repurpose (R7)	f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer	- Material & product design & development - Product development - Product marketing	Above minimum national standard	Job transformation	Medium
Reuse (R3)	m. Develop effluent treatment plants to reduce potential environmental harm and make POME a more effective fertilizer for soil health treatment p. Utilize EFB-based fertilizer for soil health treatment f. Transform OPF (Oil Palm Front; trunks, front, and leaves) into handicrafts and fertilizer	- Circular product design - Biofertilizer production - Biofertilizer application	Meet minimum national standard	Job transformation	Medium

Strategy	Technical recommendation	Circular Jobs	Work Decency	Job Impact	Shade of Green
Reduce (R2)	c. Encourage agroforestry & silvopasture that can naturally supply essential elements to reduce palm oil trees' needs for fertilizer d. Enable precise fertilizer application and prevent excessive fertilization through advanced fertilizer technology such as FOSS NIR DA2500 e. Substitute chemical pesticides with natural predators	- Material and methodology design & development - Implementation of new technique	Meet minimum national standard	Job transformation	Medium
Rethink (R1)	h. Develop Steamless Palm Oil Technology (SPOT) to streamline milling & refinery processes and reduce "liquid"-based waste	- Business development - Construction - Business management - Facilities operation - Sales & marketing	Meet minimum national standard	Job creation or substitution	Medium
	c. Encourage agroforestry & silvopasture that can naturally supply essential elements to reduce palm oil trees' needs for fertilizer	- Business development - Methodology design & development - Agricultural/ Cattle-farm supervisor - Intercrop/Cattle Farmer - Supply Chain Management	Meet minimum national standard	Job creation or substitution	Medium

To effectively support the emerging green job opportunities and meet the demands of circular and sustainable practices, individuals should develop a diverse set of skills. Proficiency in renewable energy technologies, environmental conservation, and sustainable agriculture remains critical. Additionally, expertise in circular analytics, innovation, and design, as well as circular creativity and innovation, is essential for fostering inventive solutions. Skills in agriculture management, energy efficiency, and waste management contribute to the sustainable development of green sectors.

Green construction skills, especially relevant for SPOT (Sustainable Practices in Operational Technologies), are crucial. Understanding good agricultural practices, coupled with effective communication, problem-solving, and critical thinking, are fundamental for navigating complex challenges in eco-friendly job roles. A grasp of basic software and hardware, along with ICT system design and development, enhances adaptability to technological advancements. Skills in supply chain management, negotiation, and collaboration and teamwork are indispensable for seamless integration into green industries. A willingness to learn, coupled with a strong foundation in occupational safety and health (OSH), business planning, and development, prepares individuals for dynamic roles in sustainable sectors. Proficiency in machinery operation further solidifies one's contribution to the circular economy and green job landscape.

The successful implementation of these initiatives requires strategic support from multitude stakeholders. Below is general recommendation that is applicable to all value chain:

1. Improve data collection and transparency to inform the policy and decision-making process.
2. Accelerate program and policy to reduce the existing decent work challenges, especially in the value chain where vulnerable employment is predominant
3. Maximize the green jobs potential by supporting and scaling up circular strategies
4. Facilitate and promote reskilling and up-skilling, targeting vulnerable workers, and incorporating the basic skills for green jobs and circularity in formal education.
5. Promote social dialogue to forge consensus and maintain industrial relationship
6. Create an enabling environment for collaboration and industrial symbiosis.
7. Design policy that supports an inclusive CE.
8. Link CE with sustainable palm oil initiatives

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