Design for Recycling (D4R) Guidelines for Prioritised Plastic Packagings in Indonesia

Collaborative Actions for Single-Use Plastic Prevention in South-East Asia (CAP-SEA)

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

ENVIRONMENTAL made PROTECTION in Germany

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Prepared for the Collaborative Action for Single-Use Plastic Prevention in Southeast Asia (CAP SEA) Project

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EXECUTIVE SUMMARY

Packaging plays essential roles in product management, brand identity, and consumer protection. However, it is often conflicting with environmental sustainability issues. Packaging is considered responsible for plastic waste leakage into the environment because it is not designed for recycling. Only 20% of the plastic produced in Indonesia has been designed for recycling since the beginning. As a result, 61% of plastic waste ends up burned, leaked into water bodies, or dumped on land in Indonesia.

This study aims to enable relevant stakeholders to consider a recycled-friendly packaging design, starting with developing potential D4R criteria for three-priority packaging. Literature review, Delphi survey, and stakeholder consultation are used to select priority packaging, understand the current design obstacles, develop D4R criteria, and strategise the adoption. The study reviewed 28 laws, regulations, decrees, and standards; assessed numerous statistical reports and articles; and involved 14 experts from various backgrounds in the Delphi survey, resulting in potential D4R criteria for three-priority packaging. The D4R criteria were discussed in stakeholder consultation with 40 representatives of government, upstream, and downstream stakeholders.

The priority packaging is selected based on the production scale, current recycling rate, and readiness of producers to adopt the D4R criteria. The three-priority packaging is (i) HDPE-LDPE containers for personal and home care products; (ii) PET bottles for mineral water; and (iii) PP cups for food and beverage products. The D4R criteria are broken down into eleven packaging components: the body, closure, seal and tamper, label, sleeve, barrier, additive, adhesive, ink, direct printing, and other components. Based on the current design obstacles, the fully compatible D4R criteria are monomaterial, natural or light colour, bigger size, small and easy-to-remove label, no sleeve, use only the essential additive and barrier, water-soluble adhesive, washable ink, laser marker for production and expiry dates, emboss for material logo, and easy-to-remove parts for other components. Stakeholders need further discussion regarding the minimum packaging size due to conflicting interests between downstream and upstream stakeholders. The upstream stakeholders need references for the barriers, additives, adhesives, and inks compatible with recycling, especially for non-food packaging.

The D4R guideline might impact increasing production costs, technology adjustment, and unfair competition between early adopters and reluctant adopters. The study recommends that the government provide partial grants for SMEs to adopt the D4R criteria. Big producers are encouraged to join a packaging recovery organisation where the different charge between early adopters and reluctant adopters is applied. Additional charges from reluctant adopters are managed as *Advance Recycling Fees* to attract and subsidise the downstream stakeholders in collecting and recycling the less compatible packaging. The relevant government agencies need to continue stakeholder consultation before issuing the D4R guideline.

GLOSSARY

3RproMar	A GIZ project on Reduce, Reuse, Recycle to Protect the Marine Environment and Coral Reefs
ADPII	*Aliansi Desainer Produk Industri Indonesia* (Alliance of Indonesian Industrial Product Designers)
ADUPI	*Asosiasi Daur Ulang Plastik Indonesia* (Indonesia Plastic Recycle Association)
APEKSI	*Asosiasi Pemerintah Kota Seluruh Indonesia* (Indonesian City Government Association)
APSI	*Asosiasi Pengusaha Sampah Indonesia* (Indonesian Waste Entrepreneurs Association)
ARF	Advanced Recycling Fees
ASOBSI	*Asosiasi Bank Sampah Indonesia* (Indonesian Waste Bank Association)
ASPADIN	*Asosiasi Perusahaan Air Minum dalam Kemasan Indonesia* (Association of Indonesian Packaged Drinking Water Companies)
ASPARMINAS	*Asosiasi Produsen Air Minum Kemasan Nasional* (National Association of Bottled Water Producers)
Bappenas	*Badan Perencanaan Pembangunan Nasional* (Ministry of National Development Planning)
BPKN	*Badan Perlindungan Konsumen Nasional* (National Consumer Protection Agency)
BPOM	*Badan Pengawas Obat dan Makanan* (National Agency of Drug and Food Control)
BPPT	*Badan Pengkajian dan Penerapan Teknologi* (Agency for the Assessment and Application of Technology)
BPSK	*Badan Penyelesaian Sengketa Konsumen* (Consumer Dispute Settlement Agency)
BRIN	*Badan Riset dan Inovasi Nasional* (National Research and Innovation Agency)
BSILHK	*Badan Standardisasi Instrumen Lingkungan Hidup dan Kehutanan* (KLHK's Agency for Standardisation of Environmental and Forestry Instruments)
BSN	*Badan Standardisasi Nasional* (National Standardisation Agency)
CAP-SEA	A GIZ Project on the Collaborative Actions for Single-Use Plastic

	Prevention in Southeast Asia
CAS	Conformity Assessment Scheme
CE	Circular Economy
CMMAI	*Kementerian Koordinator Bidang Kemaritiman dan Investasi* (Coordinating Ministry for Maritime Affairs and Investment)
D4R	Design for Recycling
DITJEN IKMA	*Direktorat Jenderal Industri Kecil Menengah dan Aneka* (MoI's Directorate General of Small and Medium Industries and Multifarious)
DRS	Deposit Return System
EMS	Environment Management System
EPR	Extended Producer Responsibility
EVOH	Ethylene Vinyl Alcohol
FGD	Focus Group Discussion
GIZ	*Deutsche Gesellschaft fuer Internationale Zusammenarbeit* (German Development Agency for International Cooperation)
GMP	Good Manufacturing Process
HDPE	High-Density Polyethylene
IKHF	*Industri Kimia Hilir dan Farmasi* (MoI's Directorate of Downstream Chemical and Pharmaceutical Industry)
IMINTEMGAR	*Direktorat Industri Minuman, Tembakau dan Bahan Penyegar* (MoI's Directorate of Beverage, Tobacco and Refreshment Industry)
INAPLAS	The Indonesian Olefin and Plastic Industry Association
InSWA	Indonesia Solid Waste Association
IPF	Indonesian Packaging Federation
IPI	*Ikatan Pemulung Indonesia* (Indonesian Scavengers Association)
IPR	Indonesian Plastic Recyclers
IPRO	Indonesia Packaging Recovery Organisation
Jakstrada	*Kebijakan dan Strategi Daerah* (Regional Policy and Strategy)
Jakstranas	*Kebijakan dan Strategi Nasional* (National Policy and Strategy)
KAN	*Komite Akreditasi Nasional* (National Accreditation Committee)
Kemenko PMK	*Kementerian Koordinator Bidang Pembangunan Manusia dan Kebudayaan* (Coordinating Ministry for Human Development and Cultural Affairs)

KKH PRG	*Komisi Keamanan Hayati Produk Rekayasa Genetik* (Commission on Biosafety of Genetically Engineered Products)
KKP	*Kementerian Kelautan dan Perikanan* (Ministry of Marine Affairs and Fisheries)
KLHK	*Kementerian Lingkungan Hidup dan Kehutanan* (Ministry of Environment and Forestry)
KPPU	*Komisi Pengawas Persaingan Usaha* (Commission for the Supervision of Business Competition)
LDPE	Low-Density Polyethylene
LLDPE	Linear Low-Density Polyethylene
LPK	*Lembaga Penilaian Kesesuaian* (Conformity Assessment Agency)
LSPro	*Lembaga Sertifikasi Produk* (Product Certification Agency)
MDPE	Medium-Density Polyethylene
MoEC	*Kementerian Pendidikan dan Kebudayaan* (Ministry of Education and Culture)
MoF	*Kementerian Keuangan* (Ministry of Finance)
MoI	*Kementerian Perindustrian* (Ministry of Industry)
NGO	Non-Government Organisation
NPAP	Indonesia National Plastic Action Partnership
P4SI	*Pusat Perumusan, Penerapan dan Pemberlakuan Standarisasi Industri* (Centre for Formulation, Implementation and Enforcement of Industrial Standards)
PA	Polyamide
PDU	*Pusat Daur Ulang* (Recycling Centre)
PE	Polyethylene or polythene
Pemulung	Scavenger
PET	Polyethylene Terephthalate
PETG	Polyethylene Terephthalate Glycol
PLA	Polylactic Acid
PP	Polypropylene
PRAISE	Packaging and Recycling Association for Sustainable Environment
PREPS	*Pusat Riset Ekonomi Perilaku dan Sirkuler* (BRIN's Research Centre for Behavioral and Circular Economics)

PRO	Packaging Recovery Organisation
PROPER	Public Disclosure Program for Environmental Compliance (KLHK's Award for Industrial Environmental Compliance)
PRTP	*Pusat Riset Teknologi Polimer* (Polymer Technology Research Centre)
PRTPS	*Pusat Riset Teknologi Pengujian dan Standar* (BRIN's Research Centre for Testing Technology and Standards)
PS	Polystyrene
PSIKLH	*Pusat Standardisasi Instrumen Kualitas Lingkungan Hidup* (KLHK's Centre for Standardisation of Environmental Quality Instruments)
PSLB3	*Pengelolaan Sampah dan Limbah B3—Bahan Berbahaya dan Beracun* (Waste and Hazardous Materials Management)
PT	*Perseroan Terbatas* (Limited Liability Company)
PUPR	*Kementerian Pekerjaan Umum dan Perumahan Rakyat* (Ministry of Public Work and Human Settlement)
Pusfaster	*Pusat Fasilitasi Penerapan Standar Instrumen Lingkungan Hidup dan Kehutanan* (KLHK's Centre for Facilitation of Implementation of Environmental and Forestry Instrument Standards)
PVC	Polyvinyl Chloride
PVDC	Polyvinylidene chloride
RAN-PSL	*Rencana Aksi Nasional Penanganan Sampah Laut* (National Action Plan for Handling Marine Debris)
rPET	recycled Polyethylene Terephthalate
SNI	*Standar Nasional Indonesia* (Indonesian National Standard)
SUP	Single Use Plastic
TKN-PSL	*Tim Koordinasi Nasional Penanganan Sampah Laut* (National Coordination Team for Marine Debris Handling)
TPS3R	TPS3R (3R Intermediary Waste Facility) Operators
TPST	*Tempat Pengolahan Sampah Terpadu* (Integrated Waste Management Site)
USAID	United States Agency for International Development
YLKI	*Yayasan Lembaga Konsumen Indonesia* (Indonesian Consumers Foundation)

INTRODUCTION

1.1. Background

Plastic packaging has been increasingly produced to serve human needs. It is estimated to quadruple by 2050 to 318 million tonnes annually, compared to the production in 2013 (World Economic Forum, 2016). However, there is a huge gap between plastic production, its collection, and recycling rates. The same study finds that 32% of plastics escape the collection system globally, and only 2% are recycled in a closed loop. Worse, only 20% of the total plastic produced was designed for recycling (McKinsey, 2015). As a result, much plastic waste leaks into the environment, leading to massive ecological threats. In Indonesia, 61% of plastic waste ends up burned, leaked into water bodies, or dumped on land (NPAP, 2020). According to a study by Jambeck *et al.* (2015), Indonesia is the second largest contributor of plastic marine debris in the world (1,29 million tonnes), after China (3,35 million tonnes).

The emergence of the transition towards a circular economy (CE) has been raised in the last decade. Bappenas launched Low Carbon Development in 2018 and is currently making various efforts to mainstream CE in the national development plan, incl. launching an Indonesian CE initiative book as an initial step of a Circular Economic Policy Roadmap in Indonesia (UNDP, 2022). Redesigning plastic packaging to improve recyclability has been identified as one of the circular economy opportunities in the *Wholesale and Retail Trade* sector (Bappenas, 2021).

CAP-SEA has identified the gap and intends to develop guidelines for design for recycling (D4R) for three selected groups of plastic packaging in Indonesia. The guidelines are developed by BINTARI Foundation, supported by the German Öko Institut, and in collaboration with key stakeholders. Eventually, the D4R guidelines are expected to be used in implementing a circular economy approach in plastic production and a sustainable procurement system. This initiative aims to contribute to the National Action Plan on Marine Plastic Debris[1] and the Roadmap to Waste Reduction by Producers[2].

1.2. Objectives

The overall objective of this assignment is to enable relevant stakeholders to make informed design decisions in implementing the CE approach in plastic production by supporting the development of CE product guidelines. The recyclability criteria for at least three selected product groups for packaging is developed for plastic production in the Indonesian context.

[1] Presidential Regulation 83/ 2018—70% of marine litter reduction by 2025.

[2] Minister of Environment and Forestry (KLHK) Regulation 75/ 2019—30% of packaging waste reduction through producer responsibilities by 2029.

The study focuses to develop D4R criteria for prioritized plastic packaging with meaningful participation of the related stakeholders, to get their ideas and inputs along the process and adoption after its completion.

1.3. Scope of Activities

This study focuses on investigating the production and recycling rate of (rigid) plastic packaging, current packaging policies, plastic packaging stakeholders and their interests, and recycling obstacles. Based on those understanding and comparison to the literature, the study develops potential D4R criteria for priority plastic packaging.

To achieve its objectives, this study conducts the following activity:

- Carrying out literature reviews from articles in scientific journals, research reports and other relevant publications.
- Analysing statistical data from company action plans, the government, and industrial association reports;
- Assessing and analysing promising plastic packaging segments (polymers and products) to develop D4R criteria; and
- Conducting consultations with relevant stakeholders, including government stakeholders and other related stakeholders along the value chain of plastic packaging, incl. waste collectors, recyclers, producers, manufacturers, and relevant non-government stakeholders (i.e. NGO, universities).

1.4. Research Approach and Methods

The product and packaging design may determine the extent of plastic pollution in the environment. Many types of plastic have yet to be designed for recycling since the beginning of their production, making them difficult to recycle. In Indonesia, the design and manufacturing influence the low plastic recyclability. It makes the recycling rate insignificant as only 20% while the remaining plastic waste is still not yet recycled (McKinsey, 2015). The development of plastic production regulations has been a focus to improve the circular economy because of higher recycling costs (Gradus et al., 2017). A study by Larrain, Billen, and Passel (2022) recommends direct or command-and-control interventions to increase the recycling rate in the recycling industries even though, in the long run, they might have lower effects. The level of technological innovation additionally influences the recycling rate.

The initiative of CAP-SEA to explore the CE product guideline has been a part of the direct intervention to increase the plastic recycling rate. However, it is a complex issue due to the different interests among the plastic value chain stakeholders. A previous study funded by the GIZ 3RProMar project identifies several conflicting interests, including virgin plastic investment vs plastic recycling and recyclability vs product affordability (GIZ, 2022).

The study applied the following research strategies to enable stakeholders to rethink the circular economy of packaging.

Figure 1. Flow chart of study steps.

Following the above research steps, three methods are selected and applied to proceed with the study. Detailed methods and their application in this study are described below.

1.4.1. Literature Review

A literature review is a systematic, explicit, and reproducible method to identify, evaluate, and synthesise previous similar research results that other researchers and practitioners have conducted. Its objective is to analyse and synthesise the latest knowledge (state-of-the-art) related to the topic (Okoli and Schabram, 2010). The novelty or gap is defined for the new research area based on the latest knowledge.

This research conducts a literature review for three topics: (i) to analyse and synthesise the product packaging policies; (ii) to analyse and synthesise the priority plastic packaging; and (iii) to construct state-of-the-art D4R criteria for plastic packaging. In all topics, this study follows the review steps by Polit and Hungler (1999), including defining the scope, collecting, reviewing, synthesising, and applying the literature to the research.

In the first topic, the research collected, reviewed, and synthesised 28 regulations (incl. laws, government regulations, ministerial regulation, ministerial decree, and standards) related to environmental management, waste management, waste reduction, marine litter, food safety, packaging, and alike. The review produced and synthesised the availability of regulation, the gaps, and the relationship between the regulation. The literature review on packaging policies is presented in **Chapter 2**.

Regarding priority plastic packaging, several project publications, reports, and articles are reviewed, analysed, and synthesised. This analysis is to determine three promising product packaging segments. Even though the most common plastic packaging materials worldwide are PET, HDPE, and PVC (LeBlanc Rick, 2020), it is not the case for Indonesia, where PP also plays a significant contribution. **Chapter 4** presents the analysis and synthesis of priority plastic packaging.

In the D4R criteria topic, the study reviewed, analysed, and synthesised D4R guidelines from other countries as comparisons. At least five guidelines have been reviewed, namely Circpack from SUEZ, FH Campus WIEN (2021), APCO (2020), RecyClass (2023), and The Council for PET Bottle Recycling of Japan (2016). The review provided a framework to discuss and develop D4R criteria with Indonesian plastic packaging stakeholders. The application of the review and the proposed D4R criteria for Indonesian context are presented in **Chapter 4**.

1.4.2. Delphi Method

Basically, Delphi Method is an assessment process to collect experts' opinions for making a consensus in decision-making (Carrera and Mack, 2010). The Delphi method was initially developed during the Cold War to make quick decisions among warfare experts. It was applied to quickly forecast possible attacks based on complex data in which the knowledge and experience can be extracted anonymously (Custer et al., 1999). Delphi method has three primary characteristics: (i) selection of diverse expert as respondents; (ii) anonymous among expert, but not anonymous with the researchers; and (iii) iterative process which enables experts to change their opinion without losing dignity (Okoli et al., 2004; Belanger et al., 2012).

The study used the Delphi method due to the complexity of plastic packaging circularity with multiple interests. The limited data on production and recycling rates leaves a significant knowledge gap. On the other hand, the problem is a pressing issue that needs a quick decision. The complex nature of this problem is well-suited to the characteristics of the Delphi method.

Before respondent/ expert selection, the study conducts stakeholder analysis to understand the plastic packaging stakeholders along the value chain. The result is elaborated in **Chapter 3**. Initially, the study selected 17 experts from different backgrounds and interests; however, only 14 experts gave their responses for all rounds. The experts consist of six governments, two communities, one informal, and five private sector representatives. The stakeholder selection analysis can be seen in **Annex 1**, while a complete list of Delphi resource persons can be seen in **Annex 2**.

Figure 2. Composition of Delphi experts.

The study team provides a set of questions to the experts. The questions mainly explore four issues namely (i) stakeholders of plastic packaging and their interests; (ii) prioritised plastic packaging to handle and its justification; (iii) the challenges to increase collection and recycling; and (iv) potential D4R criteria. List of questions is available in **Annex 3**. The surveys were conducted in three rounds with the following schedule:

- First round : 14 December 2022–5 January 2023
- Second round : 16–20 January 2023
- Final round : 14 February 2023

Each expert gave opinions independently and anonymously in an iterative or sequential process along the three rounds. After the first round, the study summarised and analysed the expert opinion and answers, then drew the initial consensus and presented it prior to the second round. In the second round, all experts were asked the same question. The answers were less diverse, and more consensus could be made. The study formulated the final consensus for all issues in the third round. The result of the Delphi method was then used to draft potential D4R criteria for priority plastic packaging. The draft was further discussed in the stakeholder consultation.

1.4.3. Stakeholder Consultation

Policy development is a social process. It takes not only the regulators' knowledge of the situations, but also the policy targets' awareness of the problems and how they see themselves as part of the solutions. Likewise, with the development of the D4R Guidelines, it needs to strongly engage relevant stakeholders to make informed decisions in implementing a circular economic approach in plastic packaging production in Indonesia.

The stakeholder consultation was applied as a two-way dialogue and engagement in a long process to involve the affected and other relevant stakeholders. The objective of stakeholder consultation varies from 'just' capturing views and perspectives, but also verification and validation, as well as empowering stakeholder rights (Kvam, 2017). This study designed the stakeholder consultation for two objectives: (i) to get stakeholder information and knowledge to validate the draft of D4R criteria; and (ii) to empower the stakeholders to put their interests and commitments to the proposed D4R criteria. As many stakeholders are involved, the

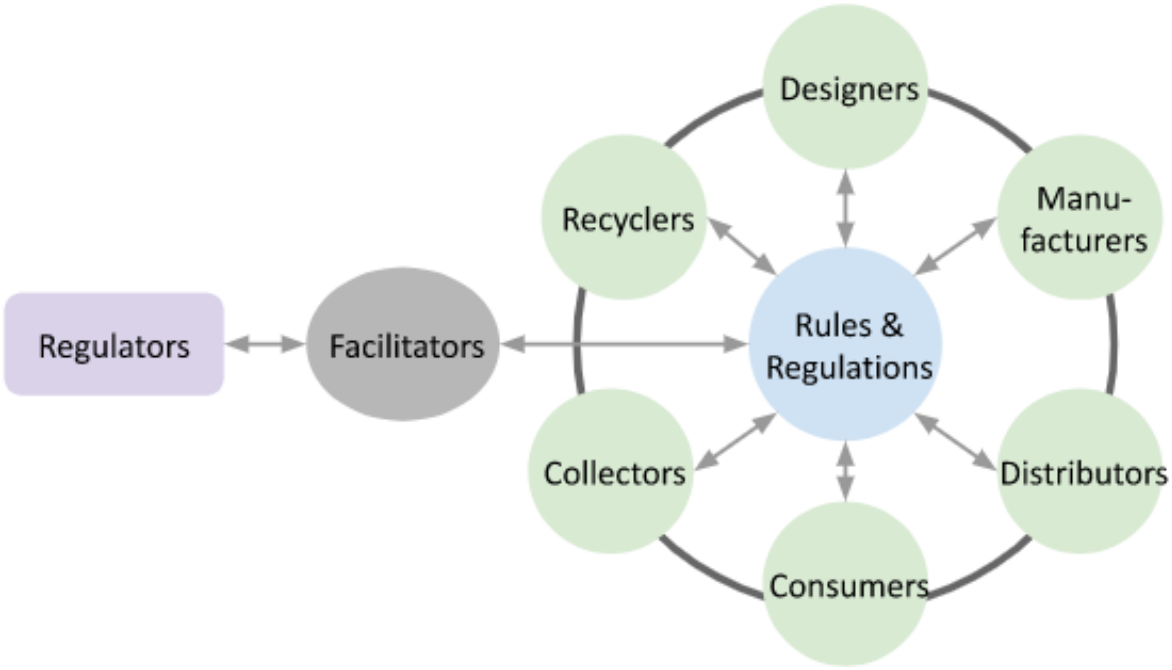

Figure 3. Stakeholder consultation in developing D4R Guidelines.

position of stakeholders toward the policy development process in the D4R guideline development can be seen in **Figure 3**.

The stakeholder consultation involved 40 stakeholders from government agencies, community representatives, producers (brand owners, manufacturers, resin traders, converters), material collectors, and recyclers.

The direct stakeholder consultation is implemented in four steps:

- The study team presented the process, findings, and initial development of D4R criteria;
- The stakeholders were invited to clarify the process, findings, and initial development of D4R criteria. The research team provided clarification without further discussion;
- Facilitators divided stakeholders into three groups representing their background and interests: government, upstream, and downstream stakeholders. Each group discussed the guiding questions and defined the most acceptable D4R criteria; and
- Facilitators set up a plenary discussion to exchange ideas, opinions, and insights for D4R refinement. All participants made consensus toward the D4R criteria by the end of the stakeholder consultation.

The results of stakeholder consultation were used to refine and finalise the D4R criteria. The results are elaborated on and presented in **Chapter 3**, **4**, and **5**. The minutes of the stakeholder consultation meeting can be found in **Annex 4**.

REVIEW OF PACKAGING POLICIES IN INDONESIA

Packaging plays important roles in goods production, storage, and distribution. When the goods arrive in its consumers, packaging provides product information, including good materials and composition, dates of production and expiry, and even the packaging material information (Guerlich, et al., 2021). Due to its important roles, the government strictly controls and regulates packaging, in particular, packaging for food products.

In Indonesia, current packaging requirements aim to respond to product protection, consumer safety, and environmental concerns. At first, packaging concerns started around food safety and consumer information (e.g. migration content, halal, allergens). Still, later it evolved to environmentally sound criteria as more environmental crises emerged and the stipulation of Indonesia's commitments on waste reduction and marine litter prevention. They expand producers' responsibilities on packaging compliance and gradually drive them to shift towards more circular business practices.

The study collates 28 policies in various forms, including laws, government regulations, ministerial regulations/ decrees, and standards. Totally 20 out of 28 policies concern the (food) product safety aspect. They mainly control the prohibited use of dangerous and toxic materials, preservatives, additives, barriers, adhesives, inks, and other substances. They also regulate labelling systems to ensure the safety aspects of products. It should cover information about expiry date, composition, production, and best before.

A total of eight regulations controls the sustainability aspect of the environment and waste, including packaging and the responsible stakeholders. They give the mandate to control environmental pollution, in which waste is one of the concerns. The waste management problems become the responsibility of all waste generators with a specific division of responsibilities among stakeholders.

The current policies reflect and deliver three critical messages, as found in the literature review. The first issue is a gap between product safety and sustainability aspects. Food safety regulations control aspects and components in detail. They refer to the materials used, including additives, adhesives, preservatives, colourants, and other substances that may potentially contaminate the product and affect its safety. The list of substances prohibited and permitted in the food industry has been clearly regulated. While it is not available for non-food products or recycling purposes.

Secondly, there is a tendency to make silos of regulation. Product safety-related regulations tend to control safety aspects and ignore sustainability issues and vice versa. The interrelation between product safety and sustainability aspects is rarely discussed in one regulation. The study only finds a few regulations that both discuss product safety and sustainability/ circularity aspects. One is SNI ISO 14009:2020 (2021) Environmental Management Systems—Guidelines for Incorporating Material Circulation in Design and Development.

The third issue is the need for supporting instruments to make regulations, standards and references being adopted by stakeholders. Some regulations have ambitious targets, i.e. waste handling, recycling targets, and prohibition of specific packaging materials. Drastic changes are expected by the common-and-control policies with limited supporting instruments. Learning points from other countries, the informative, fiscal, and economic instruments often boost to make stakeholders adopt the standards. These instruments are still lacking in the context of packaging in Indonesia.

Based on the regulatory review above, D4R criteria are beneficial in bridging sustainability, economic efficiency, and customer satisfaction interests. As the D4R criteria affect various stakeholder interests, its development must find an equilibrium to satisfy all stakeholders' interests. Summaries of relevant regulations, standards, and guidelines are summarised below, especially on the associated requirements for selected packaging groups developed in this guideline.

Table 1. Related Indonesian Policies

Policies	Summaries	Responsible/ Implementing Agencies
Environmental Protection & Marine Litter Action Plan		
Law 32/ 2009 on Environmental Protection and Management	Everyone who pollutes the environment is obliged to take action to tackle the pollution. Everyone has the right to make complaints due to alleged pollution.	KLHK.
Presidential Regulation 83/ 2018 on Marine Litter Handling	Indonesia targeted 70% marine litter reduction by 2025; it regulates the Marine Debris Handling National Action Plan 2018–2025 (RAN-PSL) and the national coordinating team (TKN-PSL) led by Kemenko Marves. In Strategy 2: Land-based Waste Management, Ministry of Industry (MoI) is in charge of encouraging upstream industries to produce compostable and easy-to-recycle plastic polymer materials, with the target of 5% of plastic production capacity; conducting a study on incentives for upstream industries; and developing GMP for easy-to-recycle plastic products. In Strategy 5: Research and development, MoI is in charge of coordinating the development of SNI of easy-to-recycle plastic products. While in Strategy 2, KLHK is mandated to regulate a ministerial regulation on waste reduction roadmap for producers.	Kemenko Marves, KLHK, and other 16 ministries/ agencies.
CMMAI Decree 69/ 2019 on RAN-PSL	The decree is a response to Presidential Regulation 83/ 2018's mandate for the Coordinating Ministry for Maritime Affairs & Investment (CMMAI) to form a team for implementing the RAN-	CMMAI (Advisor, Vice

Policies	Summaries	Responsible/ Implementing Agencies
Implementing Team	PSL. It specifies each assigned ministries' roles (until to Echelon 3 level) in marine debris handling, incl. the reporting mechanism. Strategy 2: Land-based Waste Management, is coordinated by KLHK's Director of Waste Management; some related group members: CMMAI's Deputy Assistant on Environment & Maritime Disaster, MoI's Director of Downstream Chemical Industries, MoI's Head of Research Centre & Green Industry Development, and MoF's Head of State Revenue Policy Centre. Strategy 5: Research and development is coordinated by Director of Research and Development System, National Research & Innovation Agency (BRIN); some related group members: CMMAI's Deputy Assistant on Maritime Science & Technology Utilisation, KLHK's Head of Environment & Forestry Standardisation Centre, MoI's Head of Research Centre & Green Industry Development, BPPT's Head of Environmental Technology Centre.	Chairman), KLHK (Chairman, Secretary, Coord. of Strategy 2), MoEC (Coord. of Strategy 1), KKP (Coord. of Strategy 3), MoF (Coord. of Strategy 4), BRIN (Coord. of Strategy 5).
Producers Roles in Waste Management		
Law 18/ 2008 on Waste Management	It obligates everyone/ group/ legal entity that generates waste (incl. producers) to reduce and handle their waste. [Article 14] Producers are obligated to include labels or symbols related to waste reduction and to handle on their packaging and products. [Article 15] Producers are obligated to manage their non-compostable packaging and products. Producers could get incentives/ disincentives related to waste reduction efforts.	KLHK.
Government Regulation 81/ 2012 on Management of Domestic Waste and Similar Waste	It regulates the management of domestic waste and similar waste, incl. waste reduction and handling. In waste reduction, producers are obligated to develop a decadal roadmap to limit, recycle, and utilise their waste. [Article 12] Producers have to develop a waste generation limitation plan; produce products with compostable packaging, and generate minimum waste. [Article 13] Producers have to develop a plan to reuse waste; use reusable raw materials in production; re-take products and packaging for recycling. Producers could cooperate with registered recyclers. For food recycled packaging, it has to meet the National Agency of Drug and Food Control (BPOM) standard.	Municipal governments .

Policies	Summaries	Responsible/ Implementing Agencies
	[Article 14] Producers have to develop a waste recycling plan; use reusable raw materials in production; re-take products and packaging for reuse.	
Presidential Regulation 97/ 2017 on National Policies and Strategies on Management of Domestic Waste and Similar Waste	It targets 30% waste reduction and 70% waste handling by 2025 (*Jakstranas*), which should be supported by KLHK and other ministries/ national agencies. It directs provincial & municipal governments to form the derivative regional & local strategies (*Jakstrada*) of the *Jakstranas*. The regulation also aims to strengthen the private sector's obligation to reduce waste.	KLHK, provincial & municipal governments .
KLHK Regulation 75/ 2019 on Waste Reduction Roadmap by Producers	It targets producers to reduce 30% of waste by 2029. Producers should plan, implement, monitor, evaluate, and report their efforts in waste reduction. The producers here include food, beverage, consumer goods, and personal care manufacturers. Producers could get incentives/ disincentives related to waste reduction efforts. The implementation should start in 2023. [Article 6] Waste reduction is made by limiting, recycling, and reusing the waste. Waste recycling by using recyclable/ recycled raw materials in the production process. [Article 7] In recycling and reusing the waste, producers must retake the products/ packaging. They should provide collection facilities or cooperate with registered waste banks, TPS3R and recycling centres (PDU). The recycling and reusing implementation could be in cooperation with licensed business entities. [Article 15] Producers educate consumers in choosing compostable/ recyclable/ reusable products and/ or packaging and returning those products and/ or packaging to collection facilities. KLHK authorities oversee the waste reduction efforts by producers, develop recycling rate calculation methods, define minimum recycling contents in packaging, and set the packaging label criteria. The regulation attachment specifies the detailed criteria of limitation, recycling, and reusing for each packaging type, incl. HDPE, LDPE, PET, PVC, PP, PS, aluminium cans, paper, and glasses. Some SUP products/ packaging will be phased out by 2030, e.g. 50-ml/ 50-gram sachets or less, plastic straws, polystyrene, plastic bags, & single-use cutleries.	KLHK.

Policies	Summaries	Responsible/ Implementing Agencies
KLHK Regulation 14/ 2021 on Waste Management by Waste Banks	This regulation strengthens the position of waste banks in waste management. It guides waste bank operators to expand their operations and services, incl. providing a partnership with producers to support their waste reduction efforts. The national or local government could facilitate the partnership.	KLHK, provincial, & municipal governments .
Consumer Protection & Packaging Safety		
Law 7/ 1996 on Food	The law regulated food in general, incl. food packaging and labels. [Article 16] Producers are prohibited from using food packaging declared prohibited and/ or which can release contaminants. Example in the explanation section: food with high fat content and high temperature should not be packaged in plastic packaging due to the contamination potential of carcinogenic plastic monomers. [Article 18] Restriction for repackaging, unless for food procured in large quantities, it is common to be retailed in small packaging. [Article 30] Producers are obligated to label the packaging of consumer goods. [Article 55] Punishment: imprisonment and fine.	National Food Agency, Ministry of Trade, BPOM.
Law 8/ 1999 on Consumer Protection	The law ensures consumers' rights regarding the safety of consuming goods. [Article 8] Business actors are prohibited from producing/ trading unlabeled goods, including without information on production date, expiry/ best before, and compositions. It is also prohibited to trade damaged, defective/ used and contaminated food products.	Ministry of Trade, BPSK, BPKN.
BPOM Decree HK.00.05.4.1745 / 2003 on Cosmetics	It regulates the requirement of produced/ traded cosmetics, incl. the packaging. [Article 17] Cosmetics packaging should be able to protect the products from external exposures and guarantee quality. The packaging should not contaminate the products. [Article 18] The packaging could be protected by covers. [Article 19–23] The packaging and its cover should contain product information, i.e. product name, producer's/ distributor's name and address, size/ volume/ net weight, compositions,	BPOM.

Policies	Summaries	Responsible/ Implementing Agencies
	distribution licence number, production code, expired time, other information related to safety/ quality.	
BPOM Regulation 20/ 2019 on Food Packaging	It regulates the safety of food packaging, incl. packaging from recycled materials. [Article 3] Food producers should use safe packaging materials. [Article 10] Recycled packaging production should comply with the food packaging requirements and related recycled packaging regulations. [Annexes] It specifies the food contact substances, incl.: • Restricted substances inside plastics packaging (colourants, stabilisers, plasticisers, fillers, adhesives, curing agents, antioxidants, sanitisers); • Restricted direct printing (colour inks, stabilisers, solvents); • Allowed substances with migration limits (plasticisers, antioxidants, antistatic, stabilisers, catalysts, degradants, adhesives, carriers for colourants, acetaldehyde scavengers); • Allowed substances without migration limits for plastic packaging (antifoulants, anticorrosion, antimicrobial, preservatives, antistatic antifogging, anti-blocking, release, clarifying, sanitisers, plasticisers, lubricants, foaming plastic forming, modifiers, emulsifiers/ surface active agents, fillers, stabilisers/ antioxidants, adhesives, colourants). It specifies the food contact materials, incl.: • Specifics requirements for plastic materials (limits for total migration and total heavy metals; monolayer plastics, incl. PE, PP, PET); • Specifics requirements for multilayer plastics; • Specifics requirements for closures, seals, coatings. The regulation also specifies food categorisations for each packaging type and testing procedure.	BPOM.
Government Regulation 86/ 2019 on Food Safety	It regulates food safety, incl. the stipulation of food packaging standards. [Article 24] Food producers should use safe materials for food packaging.	MoI, Ministry of Trade, BPOM, KLHK, KKH PRG, KKP, Ministry of Agriculture,

Policies	Summaries	Responsible/ Implementing Agencies
	[Article 27] Food packaging should be able to protect food quality from external exposures, be resistant to any treatments along transportation and distribution, and have good labelling.	Ministry of Health, Kemenko PMK, provincial and municipal governments.
BPOM Regulation HK.03.1.23.07.11.6664/ 2011 on Food Packaging Supervision	It prohibits using specific materials for food packaging, specifies some allowed materials, and lists materials that need pre-assessment before it applies to food packaging.	BPOM.
SNI ISO 22000 Food Safety Management System	A standard to ensure safety of food products along the value chain.	BSN.
Packaging Standards		
BSN Regulation 1/ 2019 on SNI Conformity Assessment Schemes for Rubber and Plastic Products	It regulates Conformity Assessment Schemes (CAS) for rubber and plastics products, incl. plastic containers and cups for mineral water. The schemes are used for the product certification process. [Annex] Requirements for plastic bottles certification process: • SNI 19-2946-1992 Plastic Bottles for Medicines, Food and Cosmetics; • SNI 19-4370-2004 Plastic Bottles for Drinking Water; • Minister of Trade Regulation 79/ 2019 on Obligation to Apply Labels in the Indonesian Language for Goods; • Minister of Industry Regulation 24/ 2010 on Inclusion of Food Grade and Recycling Logos on Food Plastic Packaging; • Other related SNI and BPOM regulations. Requirements for plastic cups for the drinking water certification process:	BSN, KAN, LPK, LSPro.

Policies	Summaries	Responsible/ Implementing Agencies
	• SNI 12-4259-2004 Plastic Cups for Drinking Water; • Minister of Industry Regulation 24/ 2010 on Inclusion of Food Grade and Recycling Logos on Food Plastic Packaging;	
Minister of Trade Regulation 79/ 2019 on Obligation to Apply Labels in Indonesian Language for Goods	Obligation to affix Indonesian language labels on consumer goods. It specifies the information that should be contained in the labels (e.g. material type), label types (i.e. embossed, printed, or fully attached) and label placements on the products and packaging. Some specified products: • Detergent label: product name, brand, compositions, producer's/ importer's name and address, caution symbol, and manufacturing country (*made in*).	Ministry of Trade.
Minister of Industry Regulation 24/ 2010 on Inclusion of Food Grade Logo and Recycling Code on Food Plastic Packaging	It regulates the inclusion of food grade logos and recycling codes on food packaging. [Article 2] Every food packaging should have a food-grade logo to show its food safety. The recycling code should show the plastic material type and recyclable icon. [Article 3] Both logos should use the Indonesian language, uneasy to get off from packaging, durable, and on an easy-to-see part of the packaging (visible). [Article 4] Producers should convey correct information regarding the types of plastic food packaging materials.	MoI.
BPOM Regulation 31/ 2018 Processed Food Label	It regulates the label requirements for processed food products. [Article 2] Producers and importers should provide a label on consumer goods packaging. [Article 3] The label should be visible and readable, must not be easily separated from the food packaging, and not fade/ damage easily. [Article 5] Minimum information in the label: name of product, compositions, net weight/ volume, producer's/ importer's name and address, halal symbol (for those required), production date and code, expired information, distribution licence number, and the origin of certain food ingredients. [Article 7–8] The information is written in the Indonesian language, in a readable font size (minimum Arial 0,75 mm).	BPOM.

Policies	Summaries	Responsible/ Implementing Agencies
	[Article 61] The label could contain environmental-related symbols, e.g. ecolabel, food grade, and recycling code.	
BPOM Guidelines for Processed Food Label, 2020	It guides the implementation of BPOM Regulation 31/ 2018, incl. Illustrations of example packaging.	BPOM.
SNI ISO 14009:2020 (2021) Environmental Management Systems—Guidelines for Incorporating Material Circulation in Design and Development	It provides guidelines for material circulation strategies to achieve material efficiency under the Environmental Management Systems (EMS) framework, with a spirit of building a more sustainable economy. Some EMS aspects are discussed (contexts, leadership and commitment, supporting components), and also an approach for establishing material circulation strategies for products, as well as some solutions and considerations in material circulation designs. It suggests an approach for circular ready designs: (i) circular readiness status; (ii) material circulation strategy; and (iii) design for material circulation. Altogether this will lead to an improved product. Some examples of circular readiness aspects: • Number and types of different materials used; • Recycled contents; • Ease of dismantling for recycling. Some examples of material circulation strategy and design for material circulation: • Optimising materials selection and usage; • Effective manufacturing and logistics (distribution); • Facilitating parts reuse and materials recovery. Some examples of design for material circulation: • Increasing recycled contents; • Decreasing the amount and number of different types of materials; • Selecting recyclable materials with the lowest environmental impacts.	BSN.
SNI 19-2946-1992 Plastic Bottles for Medicines, Food, and Cosmetics	It standardises the quality requirements, sampling and testing methods, passing grades, and marking requirements for plastic bottles, incl. for food and cosmetics packaging purposes. Some requirements for plastic bottles: • The materials should be made from food-grade plastics materials; • Passing physical test;	BSN.

Policies	Summaries	Responsible/ Implementing Agencies
	• Passing chemical test; • Organoleptic test; • The label incorporates the brand's name, volume, and origin country of production *(Made in Indonesia).*	
SNI 19-4370-2004 Plastic Bottles for Drinking Water	It standardises the quality requirements, sampling and testing methods, passing grades, and marking requirements for plastic bottles for drinking water. The standard aims at protecting consumers, improving the product quality, and encouraging exports. Some requirements for plastic bottles for drinking water: • The materials should be made from food-grade plastics materials; • Passing visual test (clean, no contaminants, not dented/ cracked); • Not changing the colour and odour of drinking water; • Passing full capacity, top load, leaking, and dropping tests; • Passing chemical test; • Thighly closed; • Every bottle should indicate the packaging material, producer's name-code-address, volume, amounts, and production code.	BSN.
SNI 12-4259-2004 Plastic Cups for Drinking Water	It standardises the quality requirements, sampling and testing methods, passing grades, and marking requirements for plastic cups for drinking water. The standard aims to protect consumers, improve product quality, and encourage exports. Some requirements for plastic bottles for drinking water: • The materials should be made from food-grade plastics materials; • Passing visual test (clean, no contaminants, not dented/ cracked); • Not changing the colour and odour of drinking water; • Passing full capacity, top load, and dropping tests; • Passing chemical test; • Tightly closed; • Every cup should indicate the packaging material, producer's name-code-address, volume, amounts, and production code.	BSN.
BPOM Guidelines and Criteria for Safe Recycled PET Plastics for Food Packaging, 2019	As one of the implementations of BPOM Regulation 20/ 2019, it guides the use of recycled PET (rPET) for food packaging, esp. on the safety aspects. The guidelines consist of (i) a review of PET bottle recycling policies in other countries (Australia, Europe, USA, Japan); (ii) descriptions of packaging recycling processes and technologies; and (iii) final product quality criteria.	BPOM.

Policies	Summaries	Responsible/ Implementing Agencies
	The requirements of rPET: • Clean and clear flakes with a maximum of 50 mg per of PVC contaminants, or 100 mg per kg other contaminants, and maximum 1% water; • Resin quality according to SNI 8424:2017; • For article packaging: clear and not dented, not changing odour and taste of drinking water; • Following food plastic packaging requirements of BPOM Regulation 20/ 2019.	
SNI 8424:2017 Recycled Polyethylene Terephthalate (PET) Resins	It standardises the quality requirements, sampling and testing methods, passing grades, and marking requirements for rPET resins. The standard aims at protecting consumers, ensuring the product quality, and as rPET production guidelines for producers.	BSN.

Source: the authors' construct, 2023.

- There is a huge gap of policies between product safety and sustainability aspects. Policies on product safety have been derived from laws and regulations to standards and guidelines
- Safety aspect on food products also has been strictly regulated than non-food products

PACKAGING STAKEHOLDERS AND THEIR INTERESTS

The involvement of related stakeholders since the beginning of the D4R guideline will be one of the critical enablers for a smooth CE implementation. Diverse stakeholder interests in corresponding value chain phases (see **Figure 4**) need to be expressed and discussed until a consensus with a certain satisfactory level for all parties involved can be reached. Accordingly, the study identified 14 experts from different stakeholder groups and dug into their interests, as well as how they perceive other parties' interest at the value change phases. Based on the Delphi results, some related stakeholders identified are categorised in these five CE phases, as shown in the diagram below.

Figure 4. Circular Economy diagram (European Parliament, in Anastasio, 2016).

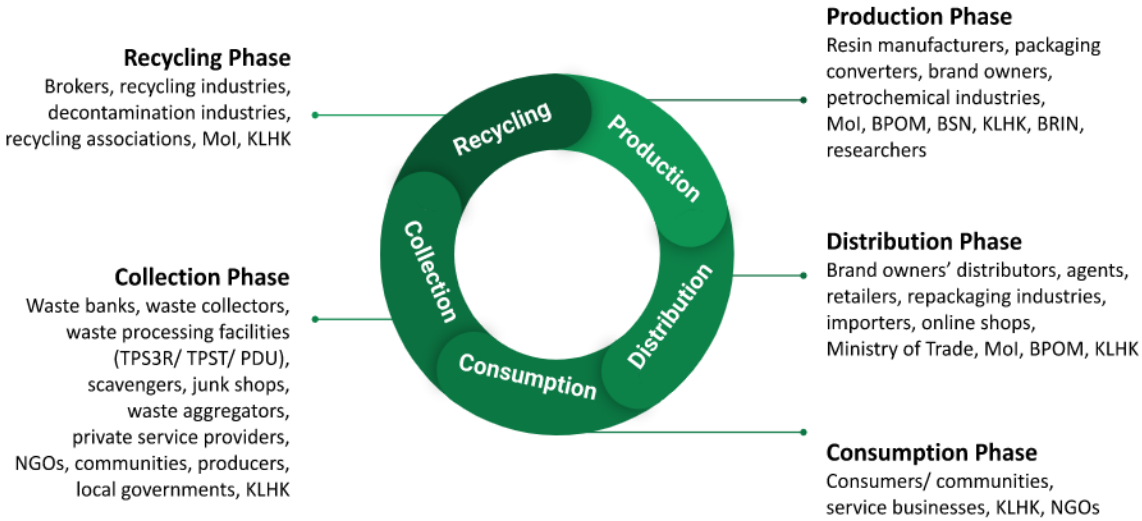

Figure 5. The phases of packaging value chain stakeholders (the authors' construct, 2023).

As they serve different functions in the packaging life cycle, each has its unique interests and needs. The repetitive Delphi survey showed that sometimes the interests would be conflicting and interplay. Their different positions towards D4R guidelines got sharpen during the consultation meeting. Some issues that emerged were minimum volume vs heavy packaging size, closure colours vs brand identity, and ink use. One decision in design criteria could bring

consequences for the profit gained, cause troubles, or even the existence of the others. More specific descriptions of stakeholder interests along the value chain are discussed as follows.

Production Phase

The stakeholders in the production phase consist of resin manufacturers, packaging producers/ converters, and product manufacturers/ brand owners. For the Indonesian context, the study team identified IPF, INAPLAS, APHINDO, Ampacet Indonesia, PT Paragon Technology & Innovation, PT Namasindo Plas, PT Chandra Asri Petrochemical Tbk and PT Dow Indonesia as implementers or associations in resin manufacturers and packaging producers; and also ADPII, an association that educate SMEs for packaging design. Most of them are classified as downstream petrochemical industries coordinated by the MoI's Directorate of Downstream Chemical and Pharmaceutical Industry. For the study purpose, these stakeholders are classified as the upstream stakeholders of plastic packaging. The table below lists petrochemical industries in Indonesia as stakeholders in packaging production.

Table 2. Related Stakeholders from Upstream Industries, based on Polymers

Polymers	Production-Phase Stakeholders
HDPE	PT Chandra Asri Petrochemical, PT Lotte Chemical Titan Nusantara
PET	PT Indorama, PT Toray Indonesia, PT Petnesia Resindo
PP	PT Chandra Asri Petrochemical, Pertamina UP III, PT Polytama Propindo

Source: USAID, 2022.

The resin manufacturers and packaging producers participate in the packaging value chain upon brand owners' requests. They have to maintain the cost competitiveness of packaging and follow some specific conditions. The specific conditions may apply as prerequisites for export or leveraging the brands' image and market attractiveness. The interests in products' packaging are to protect and guarantee the products' quality and to ensure that this message is delivered to consumers through the products' labels. Therefore, product labels are essential for brand owners. An early engagement with brand owners will play a crucial role in understanding their existing packaging design and introducing and proposing the D4R guideline as the new packaging design. Brand owners are, therefore, one of the key influencers for packaging design. Following brand owners and their associations: PRAISE, IPRO, ASPADIN, ASPARMINAS, PT Tirta Investama (Danone-Aqua Indonesia), and PT Johnson Home Hygiene Products are involved in the stakeholder consultation.

BPOM standardises the packaging regulation in Indonesia, as well as BSN (through SNI) and KLHK's BSILHK. BRIN and academics also belong to the production phase. With close collaboration with the private sector, the governmental ministry/ agency needs to guarantee the products' safety, complying with the SNI of packaging quality requirements and certain specifications for food safety. The circulated plastic packaging in Indonesia is not allowed to impact humans and the surrounding environment negatively.

Distribution Phase

The distributor of brand owners, repackaging industries, importers, online shops, and any agents and retailers belong to the stakeholders in the distribution phase. The products' safety during the distribution process is the main interest of the stakeholders. The packaging should remain intact (no leaking) and impermeable (UV-protected, water protected). In addition, the packaging should offer time flexibility: and enable the stakeholders to distribute products to resellers/ consumers on every occasion.

Similar to the production phase, the government of Indonesia also regulates the distribution through the Ministry of Trade, MoI, BPOM, and KLHK. The circulated plastic packaging during the distribution phase is not allowed to harm the environment and decreases product quality and safety for the sake of consumers.

Consumption Phase

The community/ consumers must be prioritised to obtain benefits from plastic packaging. The convenience of unpacking/ opening the packaging and re-closing the cap for storing (if leftover remains) is one of the consumers' interests. To deal with the practical needs of consumers, appropriate volumes and packaging sizes must also be taken into consideration. The plastic packaging should also be able to maintain the products' quality and hygiene, including ensuring no migration process occurs of any hazardous material penetrating from the packaging to the products. To this, the consumers often rely on the listed information from producers, which stands on the packaging label, i.e. the food grade logo. Those are the interests of consumers and some service sectors, which are also expressed by the Indonesian Consumers Foundation (YLKI). This non-governmental organisation is struggling for the rights of consumer protection. Therefore, any change or product label removal may also impact the and consumers' buying decisions.

Here, it is also important to mention the KLHK's Directorate of Waste Reduction and Directorate of Waste Management as stakeholders who regulate the post-consumption of packaging. The national movement policy to sort the waste from sources need to be supported by putting a post-consumption guideline on the packaging label, for example, by implementing an obligation for producers to put the symbol of plastic types (and the surveillance mechanism). The daily practice of waste sorting can be guaranteed by having sufficient information on the packaging label.

Collection Phase

The post-consumption of packaging should be designed to re-enter the loop of the packaging value chain. The existing regulation appoints waste banks, waste processing facilities (TPS3R/ TPST), and material recovery facilities (MRF/ PDU) as formal sectors, and scavengers, junk shops & intermediary markets, waste aggregators, SMEs as waste collectors, private waste management services as informal sectors in the collection phase. The main interest of the stakeholders in the collection phase is to generate income from the collection and segregation activity through doing the detailed-sorting activity or accessing bigger off-takers. MoI, KLHK and the municipal governments are the main stakeholders with regulatory and coaching roles in developing the knowledge and capability of all stakeholders in the collection phase (including community/ consumers).

There are particular criteria for plastic packaging that waste collectors' favour: the packaging should be easy to collect, compact in its dimension, easy to segregate and dismantle, yield

less residue, and highly valuable. Using the existing packaging designs, some collectors may collect PET bottles or HDPE containers rather than PP cups. PET and HDPE packagings meet their favoured criteria and could obtain a reasonable price from the recyclers.

Recycling Phase

In the recycling phase are brokers, recycling industries (material suppliers and resin manufacturers), decontamination industries and recycling associations. They are all also regulated by MoI and KLHK. The study team involves IPI, ASOBSI, Waste4Change, IPR, ADUPI, APSI, PT Langgeng Jaya Fiberindo—Langgeng Jaya Group, and PT Polindo Utama in the stakeholder consultations as representing stakeholders in the collection and recycling phases. For the study purpose, the collection and recycling actors are classified as downstream plastic packaging stakeholders. A literature study complements the Delphi results for mapping other stakeholders based on polymers, as follows.

Table 3. Related Stakeholders from Downstream/ Recycling Industries, based on Polymers

Polymers	Recycling-Phase Stakeholders
HDPE	Holis Usaha Plastik, Langgeng Jaya Group, PT Elastis Reka Aktif, PT Elite Recycling Indonesia, PT Eterna Persada Indonesia, PT Eco Ramah Lestari, PT Pelita Mekar Semesta, PT Pradha Karya Perkasa, PT Sumber Artha Lumbung Sejahtera, PT Sumber Plastik, Rejeki Abadi, Saudari Lombok, Sinar Indah Plastic
LDPE	Langgeng Jaya Group, PT Elastis Reka Aktif, PT Elite Recycling Indonesia, PT Eterna Persada Indonesia, PT Eco Ramah Lestari, PT Pelita Mekar Semesta, PT Pradha Karya Perkasa, PT Sumber Plastik, Rejeki Abadi, Sinar Indah Plastic
PET	Langgeng Jaya Group, Polindo Utama, PT Mega Harphi Supindo, PT Tridi Oasis Group, PT Production Recycling Indonesia, PT Rejeki Adigraha, PT Sumber Artha Lumbung Sejahtera, PT Sumber Plastik, PT Surya Indo Utama, Saudari Lombok
PP	Holis Usaha Plastik, Langgeng Jaya Group, Prima Plastindo, PT Eco Ramah Lestari, PT Pelita Mekar Semesta, PT Pradha Karya Perkasa, PT Sumber Artha Lumbung Sejahtera, PT Sumber Plastik, PT Surya Indo Utama, Rejeki Abadi, Sinar Indah Plastic

Source: ENF Ltd., 2023.

The stakeholders' interests in the recycling phase are on how to meet the quality requirements of resin manufacturers to obtain economic benefits. Consequently, the recyclers intend to collect recycling materials in huge amounts to fulfil the production capacity and gain operation effectiveness. To reach cost competitiveness, they focus on appropriate material segregation (by sorts, by colour), including minimising the residue during recycling, i.e., avoiding dirty and contaminated materials. From the point of view of recyclers, packaging labels are considered contaminating materials, which need to be small in size, easily dismantled during recycling, or fully removed using an embossed label instead.

Conflicting Interests

A D4R guideline, once implemented, will induce both positive and negative externalities for all stakeholders in the packaging value chain. Several 'conflicts of interests' among stakeholders in each phase could be noticed during the Delphi stages. Some stakeholders even expressed deep concerns during the recent stakeholder consultation. For instance, consumers need to

read the product labels before making a buying decision. Therefore, brand owners will put their best efforts into the packaging's labels for market attractiveness, and the government also obligates them to put product information on the labels for consumer protection (GOI, 2019). In contrast, recyclers consider the labels as a threat, which will raise their segregation cost or impure their recycling products. Consequently, the proposed D4R criteria are strongly influenced by the opposing interests of the stakeholders.

Some conflicts of interest on the D4R guideline might be solved during the stakeholder consultation: an intended process to engage the related stakeholders actively. The consultation aims to equalise the frequency between the stakeholders. Some consensus might be reached, for example, regarding removing tampers on the bottle's closure, which was supposed to guarantee the product's authenticity. While some brands' tampers have been removed, the closure without tampers is proposed to be set as D4R criteria. Besides the opportunity for cost savings, removing the tampers will reduce the impurity challenge during recycling.

However, the discrepancy in interest on the thickness and volumes seems not to be easily solved. Multinational brands have been aware of and concerned with this issue - they are asked to reduce virgin material use in Indonesia gradually. On the one hand, the stakeholders in the production phase hope to use thinner packaging for product safety. On the other hand, the stakeholders in the collection phase oppose the use of thinner packaging - similar efforts given in packaging collection, yet would obtain less yield. From the perspective of collectors, thinner packaging means less attractive to collect.

The discussion can shift to the ideal packaging volume for the D4R criteria. Likewise, for easy collection, the downstream stakeholders suggest the government obligate the minimum volume criteria for bottles and containers. Supporting the idea, the recyclers reveal that small-sized bottles are difficult to collect, take more time to collect, and not attractive than other packaging. The brand owners, however, are interested in providing products with affordable prices and perhaps with a certain level of volume practicality for the sake of the consumers. Therefore, the conflict of interest regarding the volume will remain unsolved.

The D4R guideline is a very complex issue. The criteria will remain in contestation as long as there are no further discussion rooms to synchronise the vision of national interests towards the CE in plastic packaging. Despite the various stakeholders' interests, the essential function of packaging needs to be prioritised as the D4R criteria. Should all of their interests be taken into account in a balanced way, the D4R guideline will be adopted with higher chances. The Government of Indonesia could carry it out as a mandatory regulation in the future.

POTENTIAL D4R CRITERIA FOR THE PRIORITISED PACKAGINGS

4.1. Selection of Plastic Packaging Priority

This study discusses the design criteria for three types of priority packaging. The fundamental challenge to come to selected packaging is to choose from the wide variety of packaging on the market. This variation includes at least the type of material and the product being packaged. Plastic packaging types are generally categorised according to the type of polymer, following the MoI Regulation 24/ 2010 concerning the inclusion of the food grade logo and the recycling code on plastic food packaging. In the interest of increasing recycling, it is also crucial to include the recycling logo and type of polymer for non-food products.

The second challenge is categorising the types of products/ goods being packaged. Goods categorisation makes it easier to point out many kinds of goods consumed and circulating in the market. The general categorisation is made for food products (food and beverages) and non-food products. However, non-food products are diverse and used for personal care, home care, and speciality goods.

The combination of packaging polymers and types of goods generates diverse product packaging categories with different characteristics and requirements. The D4R criteria for clear and specific packaging will simplify its application.

The ultimate goal of developing the D4R guideline is to reduce the leakage of plastic waste by increasing the recovery and recyclability of plastic packaging. Therefore, the research proposes three variables to select plastic packaging priority: (i) production scale; (ii) recovery/ recycling rate; (iii) and readiness of producers to adopt the guideline. Production scale plays an important factor in generating waste and its potential environmental leakage. At the same time, the recovery rate is a direct factor associated with the easiness of plastic waste to be collected and recycled. The less recycling rate indicates the more D4R guideline/ criteria. The readiness of plastic producers to adopt the guideline indicates the willingness to change into easier to recycle design.

The research conducts a three-round Delphi process to streamline priority packaging selection. In the first round, the research provides ten types of (rigid) plastic packaging to be prioritised. In this stage, the opinion of experts was still very diverse and came into seven plastic packaging priorities. Before the second round, the researchers shared the results with the participating experts to allow them to reconsider and revise their opinion in the following rounds. The result showed that the participating experts agreed to select four priority plastic packaging types: HDPE and LDPE containers for personal and home care products, PET bottles for mineral water products, and PP cups for food products. The participating experts' assessment of the selected plastic packaging is shown in the table below.

Table 4. Packaging Selection Justifications

No.	Type of Packaging	Production Scale	Recycling Rate	Readiness to Adopt
1.	HDPE bottle/ container for personal & home care products	4,6 (very high)	3,0 (medium)	3,6 (high)
2.	LDPE bottle/ container for personal & home care products	3,8 (high)	3,8 (low)	3,5 (high)
3.	PET bottle for mineral water	4,7 (very high)	1,7 (high)	4,3 (high)
4.	PP cup for food & beverage products	3,9 (high)	3,4 (medium)	3,1 (medium)

Source: the authors' construct, 2023.

At the final round, the participating experts set a consensus to proceed with the four types of plastic packaging for D4R guideline development. Despite the different opinions during the Delphi process, the participating expert agreed to prioritise four packaging types with high consensus levels, except for the PET bottle for mineral water. Only 64% of the experts agreed to pursue the D4R guideline, while 36% partially agreed. The reason to not prioritise PET Bottle for mineral water is the fact that it has been highly collected and recycled. It is consistent with the assessment result in **Table 4**. The selection of PET bottles for mineral water is influenced by producers' readiness to adopt easy-to-recycle guidelines.

How do the Delphi results compare to the reality of production and recycling rates of each selected packaging? Although comprehensive data on production and collection/ recycling rate for each type of packaging is not available, we collect some research results for comparison.

4.2. Potential D4R Criteria for Prioritised Packaging

There are many physical features and properties within plastic packaging. The physical features of bottles/ containers, tubes, cups, trays, and flexibles can vary. Each physical form has different components. The comprehensive D4R criteria highlight all components. It also covers the plastic packaging properties such as materials and colour.

Some D4R guidelines break down the physical components and define the properties. The Council for PET Bottle Recycling of Japan (2016) breaks down the physical components into the bottle's body, label, closure, and others; in each component, some aspects are defined, such as material, structure, and colour. RecyClass (2021) breaks down the component into the main body, attachments, and decoration; while several aspects are defined in each component, incl. materials, material composition, colour, size, barrier, and additives. The SUEZ Circpack elaborates its criteria in up to 13 components and aspects: main material, colour, barrier, closure system, liners–seals–valves, labels, sleeves, tamper evidence wrap, adhesives, inks, direct printing, and other components.

The study explored many criteria aspects during stakeholder engagement to test their suitability. Current and some D4R guidelines examples above benefit the study in defining the guideline aspects. Some aspects are rearranged/ combined, and others are replaced with more relevant ones. Ultimately, the study defines the physical components of packaging into eight aspects: body, closure, label, seal and tamper, sleeve, barrier, additive, adhesive, ink, direct printing, and other components. In each component, specific parameters are determined, including material, colour, size, and other parameters whenever they are relevant. We put size as an important parameter because of the diverse small sizes of products that hamper the collection of post-consumption packaging. It replaces thickness because it conflicts with the production efficiency principle.

The following sub-chapters analyse the detailed D4R criteria for those four selected plastic packaging and discuss the development process. The analysis will be divided into three sections as the study team combines the design criteria for HDPE and LDPE. More explanations related to this grouping are discussed in the sub-chapter below.

4.2.1. HDPE-LDPE Container for Personal and Home Care Products

HDPE is a strong plastic and impact resistant that is applied for shampoo bottles, liquid soap bottles, and some other personal care products. LDPE is almost similar to HDPE, but it is more flexible. It is used for producing bottles, storage boxes, toys, and tubes (Hidayat et al., 2019; USAID, 2022). Both materials have resulted from the polymerisation process of polyethylene at different pressures. While LDPE is produced under high-pressure conditions, HDPE is in the opposite condition (Karyadi, 1997). To justify the need of a D4R guideline for HDPE and LDPE containers and bottles for non-food products, the research explores three variables: production scale, recycling rate, and readiness of producers to adopt.

Selection Justification

Firstly, the production scale of HDPE containers and bottles, according to Delphi's expert opinion, is very high, while LDPE containers and bottle production are less high. To clarify this expert opinion, the research explores the country's production scale of HDPE and LDPE. HDPE production in Indonesia was 586.000 tons in 2020 (Ismawati et al., 2022). INAPLAS recorded a production scale of 800.000 tons indicating a higher figure for HDPE production. Despite the different production figures, the HDPE production scale is higher than PET. HDPE alone shares 46% of total polymer production and is considered the highest polymer production in Indonesia (MoI in USAID, 2022). LDPE is not produced locally and is still imported from other countries, including Singapore, Japan, and South Korea. It indicates a lower demand for the material (USAID, 2022).

Data on the production number of HDPE-LDPE containers and bottles for non-food products is difficult to obtain. Plastic bottles excluding PET shares 13% of the total product registered in BPOM (UNEP and MoEF Indonesia, 2020). With a variety and diverse products in the market, e.g. shampoo, liquid soap, cleansers, and other similar products, the production scale of HDPE for non-food containers and bottles can be estimated to be very high. Meanwhile, the production scale of LDPE containers and bottles for non-food is lower than experts' estimates.

The research team found it is more difficult to find LDPE containers and bottles for non-food products than HDPE packaging.

The recycling rate variable referred to in the Delphi survey is medium for HDPE containers and bottles for non-food products, while LDPE containers and bottles for non-food products are low in the recycling rate. Research indicates that HDPE rigid plastics' recycling rate is lower than PET. A survey of plastic waste recycling in urban areas of Java recorded HDPE rigid plastic recycling rate is 14% while LDPE is only 3% (Darus et al., 2020). Another survey of 54 material collectors and recyclers in the Greater Surabaya, Malang, and a small part of Greater Jakarta areas recorded a HDPE recycling rate of 4.215 tons per year. Regarding popularity (the number of actors involved in the collection and recycling), HDPE materials have engaged 25,9% of the participating actors (BINTARI, 2022). The high production scale, on the one hand, and the low to medium scale of the recycling rate give a significant argument to prioritise the development of the D4R guideline on these materials.

The third variable to justify this selection is the readiness of producers to adopt the proposed D4R guideline. The Delphi survey indicates the readiness to adopt among producers is medium to high level. In contrast to PET producers, who have made many initiatives towards recycle-friendly designs, similar initiatives for HDPE and LDPE containers and bottles for non-food products have yet to be found. The gap between the production scale and the recycling rate gives an important justification for developing a D4R guideline. Producers' participation in developing a guideline and other relevant policies can influence the producers' readiness to implement them.

The current packaging design might create circularity obstacles in two ways:

- Difficult, consume more time and energy, or not attractive to be collected because of its low prices,
- Limited material supplies, difficult to be recycled, or no recycling demands/ markets.

Recycling Obstacles in Current Design

HDPE and LDPE containers and bottles are widely used as packaging for personal and home care products such as shampoo, liquid soap, lotion, and deodorant, as well as detergent and cleaning products. Both plastic packaging has many similarities since they come from the same polymer and intended to package relatively similar products. Therefore, the study combined HDPE and LDPE containers/ bottles in one D4R criteria.

Most HDPE and LDPE bottles and containers are made thick to accommodate the liquid products; the weight of the packages is advantageous for collection. However, the current packaging design creates many obstacles to recycling the packaging. Some obstacles to collecting and recycling HDPE and LDPE containers are:

Figure 6. Examples of uneasy-to-recycle HDPE bottle.

- The cap often consists of multilayer materials and is difficult to remove. Its colours are often dark or black. The closure, especially in a tube, makes it difficult to empty the product;
- Some container or tube bodies are made from a multilayer of HDPE/ LDPE with PLA, PET, or PVC materials. It is often made in dark colour. The size is sometimes too small;
- The label is sometimes made from paper, PET, PVC or metallised materials. It covers most of the surface and is difficult to remove;
- The adhesive used to attach the labels is often left on the body of the container;
- Some containers are used aluminium and other incompatible materials as a barrier to protect from migration;
- Direct printing is still used in the body of containers;
- Recycling and material logos are often missing, too small, or unreadable.

Due to the design obstacles, some materials (containers with unremovable labels, left adhesive) often end up as residue. It also reduces the price of materials. The price of HDPE material at the recycling market is around IDR 2.000–4.000 (BSI Salatiga, 2023) per kg; IDR 1.000–8.000 per kg (BINTARI, 2022).

To increase the recyclability of HDPE/ LDPE containers, some design obstacles need to be changed to match the recycling requirements. The study explores design criteria for HDPE and LDPE containers and bottles for personal and home care products as follows.

Potential D4R Criteria

a. Body (Material, Colour, Volume)

The main concern of the bottle bodies is multilayer materials and their colours; HDPE or LDPE material is normally combined with PLA, PVC, or PET as multilayer materials. It is difficult to segregate and get pure materials. To make it compatible with recycling, the material should be HDPE or LDPE monomaterial.

Diverse and dark colours of material create an obstacle to recycling. It reduces the flexibility of material for wider purposes. To increase the recyclability of the materials, natural and white colours are the most preferable criteria.

Another concern in the HDPE or LDPE bottle and container body is the size. The thickness of the materials is fine because most of the bottles and containers have been made thick, referring to the product requirements. However, it is easy to observe that some products have

a small size (less than 100 ml); it is not attractive and easy to collect manually. Therefore, a minimum volume of 250 ml for a fully compatible category and a minimum volume of 100 ml for a limited compatible category have been suggested in the Delphi process. This proposal has not been agreed until upon the stakeholder consultation is finished.

b. Closure (Material, Colour)

The closure system in the HDPE and LDPE containers often contains several different materials; for example, PVC material is used as an outer component, while LDPE is used for the inner component. Additionally, those materials are difficult to segregate. To make it compatible with recycling interest, the material is suggested to be the same as the material for the container body. Closure materials can be HDPE, LDPE, LLDPE, and MDPE, which have similar characteristics. Making closure from PLA, PS, PVC or other materials with a density of less than 1 g/cm^3 must be avoided because it can mix with HDPE/ LDPE during the screening at the recycling process.

The second issue is the colour. Many closures are made in dark or black colours. Since the colour will influence the flexibility of material uses, it is advisable to use white or light colours.

Another issue in the closure system is the ease of emptying the product from the container. In the case of the tube, it is difficult to empty the product. Therefore, the design should pay attention to making the closure to be easy to open, empty, and close the closure system.

c. Seal and Tamper

The seals in most of the HDPE/ LDPE containers are integrated with the closure system. Therefore, the criteria, including material and colour, are similar to the closure. It is suggested to avoid using PLA, PS, PVC, aluminium, or other materials with a density of less than 1 g/cm^3.

d. Label

There are two issues in the current label designs: materials and size. Some labels use paper, PET, PETG, PS, PVC, PLA, aluminium or metallised materials. Fibre paper with strong adhesive is difficult to remove and turns all covered material into a residue. Labels from PET, PETG, PS, PVC, PLA, aluminium or metallised materials are incompatible with HDPE/ LDPE recycling.

The size of the label often covers almost all container surfaces. The label is sometimes difficult to remove because of time constraints. It is suggested to design a label less than 50% of the surface of the container body and easy to remove.

e. Barrier

Material with high density is considered effective as a barrier. During the Delphi survey and stakeholder consultation, the barrier got some attention due to some findings in the contamination of products from molecule migration. There are limited options for barrier materials in the discussion. Some literature recommends EVOH with low concentration (less than 3%) for a fully compatible category. Additionally, EVOH >5%, PA, PVDC, and aluminium barriers must be avoided because they can increase the density of materials above 1 g/cm^3.

f. Additive

None of downstream stakeholders raise their attention about additives. The upstream stakeholders, on the other side, confirm that the use of additives is unavoidable. Information about the additive effect of recycling is very limited and unobservable. Therefore, the design

criteria are determined from the literature review. The fully compatible criteria are to use only unavoidable additives and compliance.

In the food sector, BPOM issues a regulation that bans some additives that negatively impact food safety and the environment. Unfortunately, it is not applicable to personal and home care products. The stakeholders suggest establishing a similar standard for the non-food sector.

g. Adhesive

The challenge in the adhesive application is its contamination of recycling materials. The adhesive should be easy to remove or clean up to reduce its contamination. The choices are to use water-soluble adhesive without contact with the materials or not to use adhesive at all. The suggested design criteria are water-soluble adhesive for the fully compatible category. Application without leaving the adhesive in the material is suggested for the limited compatible category. Insoluble adhesive and stick in the bottle's body are not suggested because they conflict with the recycling process.

h. Sleeve

Sleeves are often used to provide insulation and additional protection from external exposures. The thickness of container materials has been considered to protect the products. Therefore, using sleeves for HDPE/ LDPE containers for personal and home care products is not advisable. For the fully compatible category, the sleeve is not suggested. Sleeves from HDPE, LDPE, LLDPE, or MDPE material are suggested for the limited category.

i. Ink

There are two concerns in ink application. The first is to prevent the product and environment from toxic inks. Safe inks are a must; however, the list of toxic inks for non-food products is unavailable. The only reference for toxic inks is released by the BPOM regulation that applies only to food products. The design criteria for ink is not toxic, with further concern to recommend the relevant government develop a list of toxic inks for non-food products as a reference.

The second issue in ink application is its contamination of the recycling materials. The contamination of inks in the recycling materials can downgrade their quality. To avoid ink contamination, the design criteria suggested using washable or removable inks during recycling.

j. Direct Printing

Using ink with direct printing on the body of containers will contaminate the recycling materials (flakes or pellets). The direct printing application should be minimised for essential information such as production and expiry dates. It is preferable to apply laser markers.

The recycling and material logos are often unavailable in many cases, making the material type difficult to recognise. The embossed printing with a readable size is recommended as a recycling criterion.

k. Other Components

Under this category, some stakeholders are concerned about using pushing equipment to dispense the products. It contains several components from different materials that are difficult to separate or remove. Therefore, the design criteria suggested using HDPE; LDPE; LLDPE; MDPE materials, or other materials but they should be easy to remove.

Based on the design criteria discussed above, the study suggests the D4R criteria for HDPE/ LDPE bottles and containers for personal and home care, as shown in the table.

Table 5. Proposed D4R Criteria for HDPE and LDPE Containers and Bottles for Personal and Home Care Products

	FULLY COMPATIBLE	LIMITED COMPATIBLE	NOT COMPATIBLE
BODY	Monomaterial HDPE or Monomaterial LDPE White or light colours Minimum volume 250 ml*	Monomaterial HDPE or Monomaterial LDPE Other colours, but not black/ dark Minimum volume 100 ml*	HDPE multilayer or LDPE multilayer with PLA; PVC; PS; PET; PETG Dark colours with carbon black Many sizes without minimum volume
CLOSURE	HDPE, LDPE, LLDPE, MDPE Easy to open, empty, & close; readable polymer symbol	PP	Foam with density <1g/cm^3, metallised materials, PS; PVC; PLA; Aluminium
SEAL & TAMPER	HDPE; LDPE; LLDPE; MDPE Seal attached in the cap	PP; PET; PETG	Foam with density <1g/cm^3, metallised material, PS; PVC; PLA; Aluminium
LABEL	HDPE; LDPE; LLDPE; MDPE; PP <50% bottle surface	Paper lost in recycling process <50% bottle surface	PET, PETG, PS, PVC, PLA, aluminium or metallised materials; >50% bottle surface
BARRIER	EVOH ≤ 3% or other essential types	EVOH ≤ 5%	EVOH >5% ; PA; PVDC; Aluminum Barrier
ADDITIVE	Unavoidable additives that do not change material density <1 g/cm^3	Mineral filler ($CaCO_3$) as long as not change material density >1 g/cm^3	Additive that change material density >1 g/cm^3
ADHESIVE	Water-soluble adhesive	Not left in the bottle body	Insoluble adhesive

	FULLY COMPATIBLE	LIMITED COMPATIBLE	NOT COMPATIBLE
SLEEVE		HDPE; LDPE; LLDPE; MDPE	PP; PET; Aluminium; metallised materials; contain much inks
INK	Washable & not toxic**	not toxic**	Not toxic or dangerous**
DIRECT PRINTING	Laser marker (production & expiry date); emboss for readable logo on recycle & material type	Direct printing limited to production & expiry date	Other type direct printing
OTHER COMPONENT	HDPE; LDPE; LLDPE; MDPE Other components should be easy to remove	PP; PET; PETG; PS; PVC; PLA	Aluminium; glass; foam with density <1 g/cm^3

Source: the authors' construct, 2023.

4.2.2. PET Bottle for Mineral Water

PET is applied in manufacturing blown bottles in the food and beverage industry and is mostly used in bottled water, soda bottles, juice, cooking oil, and food packaging. Its non-reactive nature to high gas tapping has increased its application (Rahmani et al., 2013; Hidayat et al., 2019).

Selection Justification

The Delphi result showed that the production scale of PET bottles for mineral water was considered very high. Even though data of production scale specific for PET bottles for mineral water is not available, the overall production of PET materials and water bottles can be traced. Total PET production in Indonesia in 2020 is 197.000 tons (Ismawati et al., 2022). It shares 12% of total polymer production in Indonesia (USAID, 2022).

The use of PET bottles for mineral water is massive due to the high production level of water bottled in Indonesia. In 2021, bottled water production was 30,87 billion litres of which 30% use PET bottles and PP cups (Lestari, 2022). The weight of PET bottles varies according to their volume. A water bottle of 600 ml contains, on average, 12.5 g of PET (Nurhadi, 2021). Mineral water bottles with lower volume are made from around 8 g PET, while the 1.5 litre is made from around 25 g PET material. Assuming 15% of bottled water production uses PET bottles (the other 15% is PP cup) with an average PET weight of 12.5 g per bottle, the annual production scale for PET bottles for mineral water can reach 96.469 tons in 2021. This production amount is very high compared to the overall production of PET material.

The recovery and recycling rate of PET bottles has been assessed in some research. PET bottles have been very popular for recycling material among the recycling actors including scavengers, waste banks, TPS3R, recycling material collectors, aggregators, and recyclers. A wider survey on plastic recycling in Java exhibits a PET collection rate of 20% of all recycled plastic materials, both rigid and film plastics (Darus et al., 2020), while a market survey in the Greater Jakarta Metropolitan area concluded that the recycling rate of PET bottles is 74% (Trisyanti et al., 2022). The PET collection rate is in the top three of materials being collected by material recycling actors. This finding, however, cannot estimate the recycling rate of PET bottles.

Study of 54 material collectors and recyclers in the Greater Surabaya, Malang, and small part of Greater Jakarta areas shows that more than 48.000 tons of PET bottles are collected annually (BINTARI, 2022). It indicates that the material collectors and recyclers in those areas can share about half of the PET bottles being produced. Another research on waste flow conducted by SWI claimed the collection rate of PET bottles is 62% (Danone-AQUA, 2018). All the findings above confirm that the PET recycling rate has been very high. It confirms and is in line with the Delphi assessment.

The readiness of PET bottle producers to change into easier-to-recycle designs is comparably advanced to other types of plastic packaging type. During the stakeholder consultation, some producers apply easy-to-recycle criteria, at least using PET monomaterial in the bottle body, abolishing the seal, reducing the label size, and applying laser marker. One producer has even produced an easy-to-recycle water bottle where all D4R references are applied, such as no seal, no label, PET monomaterial in the bottle body, no ink printing but embossing. This status indicates that the readiness of producers to apply D4R has been very high. This finding confirms the Delphi result on the readiness variable.

The facts and findings above have justified that PET bottles for mineral water can be a good showcase for D4R guideline development. The D4R guideline development will show a low-hanging fruit intervention that can be replicated in other types of plastic packaging.

Recycling Obstacles in Current Design

PET and PP materials are used to produce about 30% of bottled water in Indonesia. Therefore, the production number of PET bottles for mineral water is very high. However, PET bottles have been generally designed to be more recycle-friendly than other types of packaging. Its high recycling rate indicates it. Along the stakeholder engagement process, upstream and downstream stakeholders confirm that PET bottles for mineral water are mostly made from PET monomaterial in clear or bluish colour. The closure system is made mostly from PP materials which are easy to separate from the main bottle. Some manufacturers produce without tampering. The labels are made from compatible materials with a limited size covering the bottle body. A brand owner has successfully produced an easy-to-recycle PET bottle, indicating higher readiness of this sector to go for an easy-to-recycle design.

The current PET bottle design has been quite easy to recycle. However, some minor designs hamper the collection and recycling, including:

Figure 7. Examples of PET bottles for mineral water in the market.

- Some closure system still contains a PVC film that is easy to litter. The seal lefts the ring seal difficult to remove;
- Some bottle caps still contain PVC or other material with a density of more than 1 g/cm^3. Most of the cap is made in dark colour;
- Some PET bottles are too small, weighing less than 10 g. It is not attractive and easy to collect;
- Some labels cover a large space of the bottle body and are made from incompatible materials such as PVC or metallised material;
- The adhesive to stick the label is sometimes left on the bottle surface, stays during the recycling process, and remains in the flake. Some label is also difficult to remove;
- Some PET bottles have no recycling and material signs.

PET material at the recycling market is around IDR 700–7.500 at the material aggregator level and up to IDR 9.000 at the recycler per kg (BINTARI, 2022). With the current design status, it is a good practice to set up D4R criteria at a more advanced level than the other type of packaging.

The current challenge in increasing PET bottles of mineral water collection and recycling concerns the bottle size and minor components. . The minor components include the closure system, label, seal, and adhesive. PVC material is still found in the cap and label. The seal contains a ring that cannot easily be removed, and the adhesive is left on the bottle's surface. The potential design criteria have been explored below to increase the collection and recycling rate.

Potential D4R Criteria

a. Body (Material, Colour, Volume)

Bottle bodies made from PET materials with natural (clear) colour are fully compatible with recycling while PET materials with bluish colours are less compatible. Materials with dark colours and carbon black should be avoided because it reduces flexibility to use for recycling products. During the stakeholder engagement and consultation, downstream stakeholders propose to set up criteria on the thickness of the bottle body. However, increasing the material's thickness will reduce production efficiency. Therefore, regulating the thickness of materials is based on the functional purpose, including safety and product requirements.

Instead of increasing the thickness, other stakeholders propose establishing minimum volume as a criterion to make the PET bottle easy and attractive to collect and recycle—the heavier

and bigger the bottle, the more attractive and easy to collect. This proposal creates resistance among the producers because small products contribute significant market share and are handier for consumers. A minimum volume of 600 ml per bottle is suggested for fully compatible recycling.

Until the end of stakeholder consultation, stakeholders could not agree on regulating the minimum volume. It is still important to consider the minimum size as a criterion. The downstream stakeholders suggest applying minimum volume. Manufacturers can produce smaller sizes as long as giving incentives for post-consumption packaging collection.

b. Closure (Material, Colour)

The bottle lid has been collected and sold separately in the collection and recycle phase because of its different material. However, the bottle lids have many colours without any material information. To be fully compatible, the bottle lid can be made from PE or PP with a density <1 g/cm^3 in natural (clear) or white colour. In the limited compatible category, the colour is light. Bottle lids made from mixed material with PVC and aluminium with material density >1 g/cm^3 will be difficult to recycle. Dark and black colour is also not compatible with recycling purposes.

c. Seal and Tamper

Seal and tamper are normally integrated with the closure system. Even though some PET bottled mineral water has been produced without a tamper, some others still use a tamper to indicate that the bottles have not been opened. Therefore, removing tamper in the design criteria is a good practice to comply with recycling purposes fully. Under the limited category, the film tamper with strong material and easy to remove in one pulling is allowed. It is to avoid littering.

Another common challenge is the seal ring, which is difficult to remove. The seal ring is often still attached along the material supply chain. The design criteria are suggested to abolish the ring or design an easy-to-remove and integrate it with the bottle lids. When the bottle is open, the ring comes off along with the bottle cap.

The tamper and seal ring material should be similar to the lips. PVC, Silikon, and other materials with a density >1 g/cm^3 must be avoided.

d. Label

The current label has been designed in a small size. However, some incompatible materials are still found, such as PVC, PS, and metallised materials. To be fully compatible with recycling, the design criteria is to make the labels from PET, PE, or PP materials with coverage <25%. It should have a slight colour and be easy to remove.

e. Barrier

The role of barriers are to protect the product against external contamination and molecule migration. In the case of bottled water, it also protects from loss of water or absorbs water from the environment. The upstream stakeholders highly understand the role of barriers to the product. However, they do not know the effect on the recycling process. The knowledge of downstream stakeholders is limited, if not unknown because barriers are unobservable during material intake and processing.

Despite its limited information, the design criteria for a fully compatible category is without

barrier/ coating or coating with colourless material (SiOx, AlOx, COx). EVOH or PA ≤5% is suggested for the limited compatible category, while using EVOH or PA more than 5%, PVDC, and aluminium are not recommended.

f. Additive

Additive application is unavoidable in PET bottle manufacture. On the other hand, information about the additive effect of the recycling process is still limited and unobservable by the recycling stakeholders. In principle, the additive potentially contaminates the products and the flake/ pellet, hence, should be avoided as much as possible.

The use of bio/ oxo/photodegradable and nanocomposite should be avoided because it conflicts with recycling. With limited information, the design determines that the fully compatible criteria are to use only unavoidable additives and comply with BPOM regulations. Under the limited compatibility, the suggested additives are UV stabilisers and acetaldehyde inhibitors. In general, there is a need for further research in this area.

g. Adhesive

The adhesive is used mostly on the label of bottled water. It can contaminate and degrade the flake and pellet quality when it sticks and lefts on the bottle surface. To fully comply with recycling purposes, the design criteria suggested using water-soluble adhesive as a priority or using label wrapping technique without using adhesive. The use of water-soluble adhesive might increase the incremental cost. Another option is to use an adhesive that does not stick to the bottle surface. The adhesive is used only on the label.

Insoluble adhesive and sticking in the bottle's body are not suggested because they conflict with the recycling process.

h. Sleeves

Sleeves provide insulation and additional protection from external exposure to the product. The use of sleeves in bottled water in Indonesia is limited. Therefore, the design criteria suggested not using sleeves. The use of sleeves from PVC, PS, PETG, metallised material or other material with a density >1 g/cm^3 conflicts with the recycling process. Sleeves that fully cover the bottle and use many colours are also incompatible.

i. Inks

Ink can represent serious challenges in the recycling process: contaminating the materials or reducing the quality. Inks remaining in the material can alter the material colour, create defects in the final product, or degrade to form odour, gas, or migratable substances. Ink-affected materials cannot be used for new food packaging.

To be fully compatible with recycling purposes, stakeholders suggest a washable ink application. Washable ink is still expensive due to the scale of application. It can increase the incremental cost of the products.

Another challenge in ink application is regarding toxicity. Ink can be toxic and dangerous for food products. BPOM regulation clearly defines the toxic and dangerous inks that cannot be applied to food packaging. Therefore, design criteria for food packaging need to comply with the regulation.

j. Direct Printing

Like the ink application, direct printing (using ink) seriously challenges recycling material quality. However, printing might be avoidable for product traceability. Direct printing application must be reduced along the packaging design. The stakeholders suggest applying laser markers to print essential information: production and expiry dates. Another concern is to put emboss printing for the recycling logo and material type. The emboss should be clear and readable.

Under the limited compatible category, direct printing can be applied only for the production and expiry dates. Other types of direct printing are applied for non-compatible categories.

k. Other Components

Other components should be made from PE, PP, or OPP materials to comply with recycling fully. Using material with a density >1 g/cm^3 is incompatible and should be avoided. Based on the concerns and considerations above, the D4R criteria for PET bottles of mineral water are elaborated in the following table.

Table 6. Proposed D4R Criteria for PET Mineral Water Bottles

	FULLY COMPATIBLE	LIMITED COMPATIBLE	NOT COMPATIBLE
BODY	PET Natural (clear) Minimum volume 600 ml*	PET Bluish Minimal volume 330 ml*	Multilayer with PLA, PVC, PS, PETG Other dark colours; carbon black Various sizes without minimum volume
CLOSURE	PE, PP with density <1 g/cm^3; Natural (clear) or white colour	PE, PP with density <1 g/cm^3; Light colour	Mixed material with PVC & aluminium; material density >1 g/cm^3; Dark & black colour
SEAL & TAMPER	Without film tamper; Guarantee that product has not been opened without a ring seal or with ring seal attached on lid; PE, PP with density <1 g/cm^3;	PET; PE, PP density <1 g/cm^3; Tamper film easy to remove & not broken	PVC, Silikon, & others with material density >1 g/cm^3
LABEL	PET, PE, PP. <25% coverage with slight colour & easy to remove	metallised materials with density <1 g/cm^3	Other materials with density >1g/cm^3 (PVC, PS, PETG, metallised). Fibrous paper that is difficult to remove
BARRIER	Without coating or coating with colourless material (SiOx, AlOx, COx)	Multilayer with EVOH or PA ≤ 5%	Multilayer with EVOH or PA >5%; PVDC; Aluminium

	FULLY COMPATIBLE	LIMITED COMPATIBLE	NOT COMPATIBLE
ADDITIVE	Unavoidable additives & compliance to BPOM regulation	UV stabilisers & Acetaldehyde inhibitors	Bio/ oxo/ photo degradable; nano composite
ADHESIVE	Water-soluble adhesive	Adhesive that leaves no marks on the bottle main body (stick at the label)	Other type insoluble adhesive & stick in the body of the bottle
SLEEVES			Material with density >1 g/cm^3 (PVC, PS, PETG, metallised). Sleeves full cover & use many colours
INK	Washable, not toxic & comply with BPOM regulation	Not toxic & comply with BPOM regulation	Toxic or dangerous ink
DIRECT PRINTING	Laser marker (production & expiry date); emboss for readable logo on recycle & material type	Direct printing limited to production & expiry date	Other type direct printing
OTHER COMPONENT	Made from PE, PP, or OPP materials		Other plastic with density >1 g/cm^3

Source: the authors' construct, 2023.

4.2.3. PP Cups for Food and Beverage Products

Polypropylene (PP) is used for food containers, home appliances, drug bottle caps, and automotives because of its ease to form in high temperatures, flexible, hard, and resistant to fat (Hidayat et al., 2019; USAID, 2022). Polypropylene (PP) is used for food containers, home appliances, drug bottle caps, and automobiles because of its ease of forming in high temperatures, flexibility, hardness, and fat resistance (Hidayat et al., 2019; USAID, 2022). It is a free-colour material with excellent mechanical properties (Maddah, A.H., 2016). This promising application makes PP widely used in many sectors, including the packaging industry. This material is the most recommended material for D4R Guideline development selected by Delphi experts. The following part explores production scale, recycling rate, and readiness of producers to design easy-to-recycle packaging to justify the need for D4R guidelines. The following part explores production scale, recycling rate, and readiness of producers to design easy-to-recycle packaging to justify the need for D4R guidelines. This material is the most recommended materials selected by the Delphi experts.

Selection Justification

The Delphi survey indicates the need to prioritise a D4R guideline for PP containers and cups for food products because of its wide application. The production scale is high with a 3,9 of 5 scales. According to Ismawati et. (2022), the total production of PP was 935.000 tons in 2020. A slightly lower production is reported by INAPLAS, where PP production is recorded at 880.000 tons while the demand was 1.800.000 tons in 2022. To fulfil the demand, the national industry imports 920.000 tons.

The diverse use of PP as containers and cups in food and beverage sectors indicates the significantly high application of PP materials.

According to the Delphi survey, the recycling rate of PP containers and cups for food products is medium. The survey of plastic waste recycling in urban areas of Java recorded that PP rigid plastic recycling shares 25% of total plastic recycling. It is considered to have the highest recycling rate among other types of plastics (Darus et al., 2020). A survey of the material collectors and recyclers in the Greater Surabaya, Malang, and a small part of Greater Jakarta areas recorded PP collection and recycling at around 5.000 tons per year (BINTARI, 2022). However, PP rigid plastic is often used for home appliances heavier than food containers. Therefore, the recycling rate is still low to medium scale.

The producers using PP containers and cups are highly diverse, from small-scale to multinational companies. Therefore, the readiness of producers should be assessed differently. National manufacturers, as a priority, tend to have a better readiness than small-scale industries. Some observable food containers of national producers have applied an easy-to-recycle principle such as no ink printing at the container body and laser marker. At the retail and small-scale food producers, the PP containers often have ink printing, paper labels, strong adhesive, and so on.

Given the fact that the production scale of PP containers for food products is high, but the recycling rate is between low to medium, the development of D4R is highly justified.

Recycling Obstacles in Current Design

PP cups are widely used in food and beverage sectors to pack mineral water, tea, coffee, jelly, and pudding. About 30% of mineral water products are partly packed in PP cups, while other parts are packed in PET bottles. Besides being used by manufacturers, it is also locally produced and used by local producers such as cafes, restaurants, and hotels for their takeaway drinking products. The material price of PP cups is diverse in the range of IDR 2.000–10.000 per kg, depending on the supply chain level. The natural PP cup price at the junk shops and aggregators is between IDR 2.000–6.000, while the coloured PP cup price is slightly cheaper, between IDR 2.000–3.000 per kg (BINTARI, 2022; 2023).

Besides the colour, the price of PP cups is very likely influenced by their design. The natural PP cup without ink printing (e.g. mineral water cups) tends to be more expensive than the coloured or printed PP cups. The figure on the side shows the typology of the recycling obstacle in the PP cup design for food and beverage products.

Figure 8. Examples of PP cups in the market.

- Most of the PP cup lid tends to be difficult to open or remove;
- PP cup body has a small size, especially for jelly products;
- Some PP cup bodies are often used for direct printing of product labels;
- Adhesive remains at the cup body;
- Sometimes the labels are printed in a different layer on the body, but it covers all the cup surface;
- Recycling and material symbols are often unavailable.

The current PP cup packaging design needs to be transformed for effective recycling. Most PP cup lids are designed to use a straw. Therefore, it is difficult to open and remove. The cup lids often remain at the cup lips and contaminate the body. The PP cup size is often very small, for example in jelly products for kids. Even though the material price is high, collectors need extra time and energy to collect them. The PP cup bodies are often contaminated by ink or adhesive. When attaching labels, the labels are printed directly on the cup surface, while the adhesive is left on the cup lids or on the cup surface.

Potential D4R Criteria

To reduce the collection and recycling barriers, the D4R criteria should consider some principle aspects:

a. Body (Material, Colour, Volume)

The PP cup bodies will be fully compatible when they are made from PP monomaterial. Multilayer PP material with PLA, PVC, PS, and PETG should be avoided to keep the PP materials safe. The natural and white colours are preferable to give flexibility in using the recycling products. It is still partly compatible when the colours are bluish or light colours—the dark and black colours or black carbon disadvantages the recycling products.

The size of PP cups, similar to other packaging, is a hard negotiating issue between upstream and downstream stakeholders. Some cups have been designed in extremely small sizes (e.g., bite-sized) that tend to cause littering. The study recommends a minimum volume of 240 ml per cup for the fully compatible category and 100 ml for the limited compatible category.

b. Closure (Material, Colour)

Material and colour for closure will be preferable when it is the same as the cup body. Closure from PP material with natural or white colours suits me very much with recycling interest. Under

the limited category, the closure can be designed with HDPE, LDPE, LLDPE, or MDPE with bluish or light colours. Closure from aluminium, metallised, or mixed materials with a density of less than 1 g/cm^3 will easily contaminate PP material during the recycling process.

c. Seal and Tamper

The design for the seal is expected to be the same as the closure in terms of material and colour. The seal is normally integrated or combined with a closure system in the PP cup design. Sometimes, it can be separated where the seal is installed and protected by a closure.

d. Label

The label gives essential information about the products. Some products provide labels on the closure, while others install a plastic layer at the cup body. The label designed for the cup lids, in general, is preferable because it will reduce the effort to clean up the cup body. The material and colour for the label are the same as the closure. When the label is designed on the cup body, it should be printed separately on a PP sheet in natural or white colour. Direct printing of labels to the cup body should be avoided to maintain the quality of recycling materials.

e. Barrier

There is a limited discussion about the barrier during the Delphi survey and stakeholder consultation. Due to the essential role of a barrier to protect the product from molecule migration and external contamination, the barrier has been regulated in the Perka BPOM. The use of barriers should comply with BPOM regulations. This study suggests using EVOH (Ethylene Vinyl Alcohol). Application of EVOH less than 6% is compatible with recycling according to other D4R guidelines (Circpack; RecyClass, 2021).

f. Additive

The additive for food packaging has been clearly regulated in BPOM regulation on food packaging. The D4R criteria suggest compliance with the regulation. Under the fully compatible category is to use the essential additive that does not change the material density to less than 1 g/cm^3. Material filler ($CaCO_3$) can be used in the limited compatible category.

g. Adhesive

The adhesive is used at the closure system and at attaching the label. Since adhesive might contaminate or reduce the quality of recycling materials, the adhesive should be used without remaining in the cup lid or body. The use of adhesive in PP cups should also comply with BPOM regulations on food packaging.

h. Sleeve

The sleeves are widely used to protect PP cup packaging. The sleeve materials can be paper or plastic. The use of PVC, PS, PETG, and metallised materials should be avoided to ensure the safety aspects of food and beverage products. The study also recommends limiting the sleeve size to minimise the residue.

i. Ink

Ink causes serious contamination and reduces recycling material quality when applied directly

to the materials. Therefore, the PP cup body should be clear from the ink application. Stakeholders and literature suggest using non-toxic ink to be fully compatible with recycling purposes. The washable ink is suggested for the fully compatible category. Regarding toxicity, the use of ink should comply with BPOM regulations on food packaging.

j. Direct Printing

Direct printing causes significant contamination to the recycling material quality. Unfortunately, direct printing with large coverage is still easily found in several PP cups. Direct printing is limited for production and expiry dates to increase recyclability. It is preferable to use laser markers instead of other types of printing. Emboss printing for recycling and material logos are suggested in a readable scale to make the sorting easier.

k. Other Components

The use of plastic materials for other components is limited. However, if it is relevant to users, the study suggests avoiding plastic materials with a density of less than 1 g/cm^3.

Based on the discussion above, the study concludes and recommends D4R criteria for PP cups for food and beverage products, as shown in the table below.

Table 7. Proposed D4R Criteria for PP Cups for Food and Beverages Packaging

	FULLY COMPATIBLE	LIMITED COMPATIBLE	NOT COMPATIBLE
BODY	Monomaterial PP Natural; white Minimum volume 240 ml*	Monomaterial PP Bluish; light colours Minimum volume 100 ml*	Multilayer PP with PLA; PVC; PS; PETG Dark colour; black; Carbon black Many sizes without minimum volume
CLOSURE	PP Natural (Clear); white	HDPE; LDPE; LLDPE; MDPE; Bluish; light colour	PVC; aluminium; other mixed materials with density <1 g/cm^3
SEAL & TAMPER	PP Natural (Clear); white	PET; PE; PP; other materials with density >1 g/ cm^3	PVC; Silicone; other materials with density < 1 g/cm^3
LABEL	PP Natural (Clear); white Label in the cup lid or cover the cup body < 50% Label easy to be removed	Metalized materials with density >1 g/cm3	PVC, PS, PETG, metalized materials Other materials with density <1g/cm3 Label covers the cup body > 50% and difficult to be removed
BARRIER	EVOH ≤6%	EVOH >6%	EVOH with different tie layers; PA; PVDC; Aluminium

ADDITIVE	Unavoidable additives as long as not changing material density < 1 g/cm³ Comply with BPOM regulation	Mineral filler (CaCO3) as long as not changing material density < 1 g/cm³ Comply with BPOM regulation	Additives that change material density > 1 g/cm³
ADHESIVE	Does not left on the rim of the cup or the body		left on the rim of the cup or the body
SLEEVES			Materials with density <1 g/cm³ (PVC, PS, PETG, metallised). Full cover with many colours
INK	Washable Not toxic & comply with BPOM regulation	Not toxic & comply with BPOM regulation	Toxic & dangerous inks
DIRECT PRINTING	Laser marker (production & expiry dates); emboss (readable material type & recycling)	Direct printing only for production & expiry dates	Other types of direct printing.
OTHER COMPONENT			Other plastic materials with density <1 g/cm³

Source: the authors' construct, 2023.

4.3. Fostering D4R Criteria Adoptions

Among the above design criteria, some criteria need additional follow-up. The size of the packaging remains an unagreed criterion between the participating stakeholders. The downstream stakeholders argue to limit the minimum size to prevent ease in collecting the packaging. The upstream stakeholder interest is to provide affordable products. Both stakeholders agree to let the government decide the minimum size or continue the discussion before the 'legalisation' of the D4R guideline.

Additionally, the upstream stakeholders need clarification on the ink toxicity criteria. Currently, the reference for toxic ink (also relevant for barrier, additives, and adhesive) is the BPOM Regulation 20/ 2019 about food packaging. However, it is specific to food packaging and does not apply to personal and home care products. Upstream stakeholders suggest issuing special references for non-food products. The effect of the additive and barrier is still a wide subject for further research in other countries (Guerlich, Kladnik and Pavlovic, 2021).

The proposed D4R criteria can have different consequences for stakeholders, for example: between multinational and small-medium companies; between the early adopters and reluctant adopters; and between upstream and downstream stakeholders. The consequence

should be managed to maintain the material circulatory moving by providing supporting strategies or supporting instruments.

The different consequences between multinational and small-medium companies might occur when the proposed D4R criteria might create incremental costs, i.e. applying washable ink, soluble adhesive, or laser markers. It might create difficulties especially for the small-medium companies due to their lack of capacity and financial capital. The government needs to assess its impact, especially the SMEs for adopting the D4R guideline, it is necessary to provide mitigation policies. The mitigation policies provide the gap cost to adopt the D4R guideline. Study of CAP-SEA Project in Economic and Fiscal Measure suggests to provide a partial grant or subsidy for technology and material adjustment to increase the material circularity (Dirgantara, 2023).

The D4R guideline might be responded differently among the producers that lead to the early adopters and reluctant adopters. Early and reluctant adopters in adopting D4R guidelines might occur and need to be managed because it can create an unfair business climate among the producers. Since the nature of the guideline is voluntary, the government has less influence to push the adoption. In this case, the government needs to facilitate adoption mechanisms in the producer association or Packaging Recovery Organisation (PRO). The cost to collect, take back, and or recycle can be calculated to measure the consequence of not adopting the D4R criteria. For example, companies using washable ink will create ease in recycling the materials, while companies using normal ink for direct printing at the container surface will reduce the recycling material values. The gap cost in avoiding the application of ink criteria should be charged extra by the association or PRO to the reluctant adopters to provide a fair business climate.

Last, the D4R guideline should provide an equilibrium of interest between upstream and downstream stakeholders to maintain the material circularity. The minimum size represents conflicting interests between material collection and production. Increasing the minimum size protects the collector's interest in an easy and valuable material collection, but it disadvantages the producers in providing affordable products. In this case, setting up a minimum size that gives equal interest for both material collectors and producers can be an option. However, when they cannot meet the agreement, and the size is still too small, the producers can provide subsidies for the collectors. Similar cases might happen with other criteria that hamper recycling processes such as ink, adhesive, or direct printing applications. The recyclers need extra effort to run the circularity. Therefore, they need financial compensation. The Advanced Recycling Fees (ARF) can be a potential alternative to provide subsidy from the reluctant adopters to the downstream stakeholders. It is normally applied to maintain circularity. This instrument is typically used to fund the material collection and recycling feasibility gap. This model has been applied in several countries, such as Japan and Taiwan (Atasu and Subramanian, 2012). The Deposit Return System (DRS) might also be applied to increase the post-consumption material collection. The DRS incentivises customers to sort and collect specific packaging to support recycling (Gupt and Sahay, 2015). However, it might increase the collection rate only but not solve the recyclability when the recycling obstacles (poor design for recycling) are not addressed.

At the end, the supporting instruments and strategies are importantly needed to maintain the circularity.

CONCLUSION & RECOMMENDATION

5.1. Conclusions

In developing recyclability criteria for priority plastic packaging, the study reviews packaging's regulatory requirements and standards and discusses them with relevant stakeholders along the value chain. Stakeholder engagement is pursued by adopting the Delphi method—where 14 experts representing relevant stakeholders select priority plastic packaging and establish D4R criteria. Besides that, a stakeholder consultation meeting also takes place where more than 40 stakeholder representatives clarify, verify, and agree on the proposed D4R criteria.

The study highlights several important conclusions to increase plastic packaging recyclability:

- Packaging plays essential roles in product protection, consumer safety, and environmental sustainability. The relevant government institution has individually regulated the three aspects; however, limited standards and requirements have not been meeting the equilibrium of all aspects. The policy gaps are obvious that give more control on food products than non-food products;
- The stakeholder interests represent the tug of product protection, consumer safety, and environmental sustainability aspects. Engagement of stakeholders and establishment of consensus between the stakeholders within the D4R criteria can keep the circularity run;
- Based on the production scale, current recycling rate, and the readiness of producers in Indonesia, D4R criteria are needed for three plastic packaging: (i) HDPE/ LDPE containers for personal and home care products; (ii) PET bottles for mineral water; and (iii) PP cups for food and beverages products;
- The study proposes potential D4R criteria for three plastic packaging divided into 13 components. Most criteria have been agreed upon between participating stakeholders, except the minimum size/ volume of products. Moreover, shifting to a more recyclable design might increase the incremental cost of products and additional references and facilitate a fair adoption.

The implementation of D4R criteria might influence the stakeholders differently due to their (economic) scale or other factors. The responsible government agencies must prepare mitigation strategies before implementing the D4R guideline.

5.2. Recommendations

This study provides a basis for the relevant ministries to develop D4R guidelines for three-priority plastic packaging. It produces potential D4R criteria for most packaging components, including packaging body, closure, seal and tamper, label, sleeve, direct printing, and other components. However, the study needs further steps to proceed into an effective guideline and its implementation. Therefore, the study recommends the following actions:

a. Continuing the stakeholder dialogues along the D4R guideline development to agree on all components of D4R criteria, especially related to minimum size, ink, additive, adhesive, and barrier. The minimum size of products needs to find an equilibrium between the ease of collection by downstream stakeholders and the affordability of products. For the ink, additive, barrier, and adhesive application, producers need a special reference for non-toxic ink for non-food product packaging as the food product packaging has been regulated by BPOM regulation.
b. Providing standards and references for the ink, additive, barrier, and adhesive application for non-food products to fill the policy gap. Relevant ministries need to conduct studies to investigate the effect of ink, additive, barrier, and adhesive to the products, recycled materials, human, and environment. The standard and reference should be issued to guide producers to select the application for non-toxic ink for non-food product packaging.
c. Mitigating the impacts of D4R guideline implementation as some criteria will increase the incremental cost of products, namely related to laser marker, washable ink, and water-soluble adhesive. The relevant ministries need to calculate the additional cost of adopting the D4R guideline and provide a partial grant, subsidy, or other fiscal incentives for technology and material adjustments, especially for small and medium producers.
d. Promoting and facilitating the upstream stakeholders to adopt the D4R guideline implementation to their product packaging. Naturally, the D4R guideline is a voluntary instrument; however, the relevant ministries need to encourage the adoption by integrating D4R implementation into available instruments (e.g. PROPER, IPRO memberships, monitoring of waste reduction by producers).
e. Facilitating a fair waste reduction mechanism for similar producers. The relevant ministries need to strengthen IPRO as a platform for joint waste reduction by producers. IPRO should use the D4R guideline as a basis for valuation instruments to calculate the cost of adoption and ignorance. Reluctant producers would get a higher charge as compensation for collection and recycling challenges. This charge is transferred as an ARF to maintain material circularity.
f. Facilitating the financial transfer of ARF from upstream to downstream stakeholders to keep material circularity run. The waste collectors and recyclers who handle difficult-to-recycle packaging receive ARF to keep the circularity running, as the packaging that does not follow the D4R guideline will create difficulties in the collection and recycling process.

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ANNEX 1: STAKEHOLDER SELECTION

Stakeholders	Value Chain	Involvement in the Study		D4R related Responsibilities, Interests, & Selection Justification
		Delphi	Consultation Meeting	
A. Government				
1. CMMAI (Assistant Deputy for Waste & Wastewater Management)	All		v	• Coordinator of Indonesia's Marine Litter Reduction target—70% marine litter reduction by 2025; have strong visions in increasing recycling. • Have coordination function—able to lead & coordinate inter-sectoral ministries.
2. MoI (IKHF; Green Industry Centre; P4SI, IMINTEMGAR, DITJEN IKMA)	Production, Recycling	v	v	• Coordinate plastic investments & production (incl. virgin-recycling plastics); plan & foster industrial standardisation. • Encourage upstream industries to produce recyclable plastic materials (develop incentives, GMP, SNI). • Encourage growth of recycling industries; guide recyclers & local governments on selecting plastic waste as raw materials. • Support KLHK on EPR policy development, sorting & utilising plastic waste training to cities/ districts. • Represent industrial interests.
3. KLHK (Directorate of Waste Reduction; PSIKLH-BSILHK, Pusfaster-BSILHK)	Production Consumption ,Collection, Recycling	v	v	• Head of National Committee for Marine Litter Reduction (TKN-PSL). • Have a mandate in waste management & reduction, regulate EPR implementation, eco product standardisation. • Support MoI in drafting recyclable plastic SNI regulations. • Represent environmental interests.

Stakeholders	Value Chain	Involvement in the Study		D4R related Responsibilities, Interests, & Selection Justification
		Delphi	Consultation Meeting	
4. BRIN (PRTPS; Research Centre for Sustainable Production Systems and LCA; Polymer Technology Centre; PREPS)	Production, Collection, Recycling	v	v	• Organise research utilisation & innovation policies; encourage the discoveries of alternative materials. • Support KLHK on sorting & utilising plastic waste training to cities/ districts; increasing utilised plastic waste. • Support MoI on encouraging upstream industries to produce recyclable plastic materials. • Give information about the current research/ innovation updates.
5. BPOM (Directorate of Processed Food Standardisation; Dit. SOTSKK)	Production	v	v	• Responsible for protecting public health (incl. food safety); regulate standardisation of safety, benefits, quality, food packaging safety. • Support MoI in developing GMP guidelines for recyclable plastic products. • Give information about consumers' health & safety aspects.
6. BSN (Dit. PSAKKH)	Production	v	v	• Technical body related to standard formulation. • Support MoI in drafting recyclable plastic SNI regulations.
7. Bappenas (Directorate of Environment)	All		v	• Coordinate & build capacity for development planning for Low Carbon Development and Green Economy in Indonesia.
8. Municipal Government	Consumption ,Collection, Recycling		v	• Have a mandate in managing waste at the local level; have interest in reducing waste to landfill & waste league to the environment. • Regulate single-use plastic banning regulation.
B. Civil Society				
9. NGOs	Production,	v	v	• Have vision in proper waste management & clean cities.

Stakeholders	Value Chain	Involvement in the Study		D4R related Responsibilities, Interests, & Selection Justification
		Delphi	Consultation Meeting	
	Consumption ,Collection, Recycling			• Did advocacy to some strategic waste regulations. • Represent cross cutting issues.
10. Academicians	Production	v	v	• Give information about the current research/ innovation updates, esp. on food packaging.
11. Consumers	Consumption		v	• Have vision in increasing consumers' critical concern for their rights. • Represent consumers' interests in food safety, affordability.
C. Informal Sector & Service Provider				
12. Scavengers	Collection, Recycling	v	v	• Recover post-consumption plastic waste from consumers. • As raw material providers for waste aggregators & recycling industries. • Give insights from material collection perspectives & available sorting technologies.
13. Waste Entrepreneurs	Collection, Recycling	v	v	• Provide waste collection & transportation services. • Aggregate & recycle plastic waste. • Give insights from material collection perspectives & available sorting technologies.
14. Waste Banks	Collection		v	• Recover post-consumption plastic waste from consumers. • As raw material providers for waste aggregators & recycling industries. • Give insights from material collection perspectives & available sorting technologies.
15. Waste service providers	Collection		v	• Recover post-consumption plastic waste from consumers. • As raw material providers for waste aggregators & recycling industries.

Stakeholders	Value Chain	Involvement in the Study		D4R related Responsibilities, Interests, & Selection Justification
		Delphi	Consultation Meeting	
				• Give insights from material collection perspectives & available sorting technologies.
D. Private Sector				
16. Resin producers	Production		v	• As plastic producers. • Represent the resin producers' perspectives; give information on materials-designs-technologies for packaging.
17. Resin converters	Production	v	v	• As resin & packaging producers; players in packaging business & investment. • Represent the packaging producers' perspectives; give information on materials-designs-technologies for packaging.
18. Manufacturers	Production		v	• As product producers. • EPR implementers. • Represent manufacturer interests.
19. Packaging Recovery Organisation	Production, Collection	v	v	• EPR implementers. • Represent manufacturer interests.
20. Recyclers	Recycling	v	v	• Represent recyclers' interests. • Give information on available technologies for recycling.

ANNEX 2: DELPHI RESOURCE PERSONS

Line Ministries and National Agencies

1. **MoI**—Directorate of Downstream Chemical and Pharmaceutical Industry (IKHF)
2. **KLHK**—Directorate of Waste Reduction
3. **KLHK**—Centre for Standardisation of Environmental Quality Instruments
4. **BRIN**—Research Centre for Testing Technology and Standards
5. **BPOM**—Directorate of Processed Food Standardisation
6. **BSN**—Directorate of Development of Agro, Chemical, Health and Halal Standards

Communities

7. Indonesia Solid Waste Association (**InSWA**)
8. Soegijapranata Catholic University (**UNIKA**)

Informal Sector

9. Ikatan Pemulung Indonesia/ Indonesian Scavengers Association (**IPI**)

Private Sector

10. Indonesia Packaging Federation (**IPF**)
11. Indonesian Plastic Recyclers (**IPR**)
12. Asosiasi Pengusaha Sampah Indonesia (**APSI**)
13. Indonesian Packaging Recovery Organisation (**IPRO**)
14. Packaging and Recycling Association for Sustainable Environment (**PRAISE**)

ANNEX 3: DELPHI SURVEY QUESTIONS

1. Who are the stakeholders of plastic packaging along their value chain?
2. What are their interests toward plastic packaging design?
3. Please choose three types of plastic packaging that have the potential to increase recycling rate if the D4R guidelines are developed.
4. Please provide your justifications on its production scale, recovery/ recycling rate, and readiness of stakeholder to adopt the guideline.
5. What are the main obstacles to collect and recycle the packaging due to the design aspect?
6. What are the design criteria to reduce the collection and recycling obstacles?

ANNEX 4: STAKEHOLDER CONSULTATION MINUTE OF MEETING

Event : Stakeholder Consultation Meeting for Design for Recycling (D4R) Guideline Development

Date, time : 22 February 2023, 9am–5pm

Venue : Pullman Hotel, Jakarta, Indonesia; partly online by Zoom

Participants : 49 people joined in person, 18 people online (some people join both alternately) represented 40 entities:

- GIZ and study team: CAP-SEA, 3RproMar, BINTARI Foundation;
- National government (7 ministries/ agencies): CMMAI, MoI, KLHK, BPOM, BSN, BRIN, Ministry of Trade;
- Local government: APEKSI;
- Producers (7 associations and 5 companies): IPF, ASPADIN, ASPARMINAS, INAPLAS, PRAISE, IPRO, PT Tirta Investama (Danone - Aqua Indonesia), PT Johnson Home Hygiene Products, PT Namasindoplas, PT Chandra Asri Petrochemical Tbk, PT Dow Indonesia;
- Design Association: ADPII
- Communities: YLKI;
- Collectors & Recyclers (4 associations & 3 companies): ADUPI, APSI, ASOBSI, IPR, Waste4Change, PT Langgeng Jaya Fiberindo, PT Polindo Utama; and
- Researchers/ Policy Advisors: UNIKA, InSWA, Sea The Future/ Asia Group Advisors.

Event summaries:

1. Opening Remarks
   a. Mr Rendra Hasan, Waste Handling Coordinator, CMMAI:
      - Appreciation for GIZ as a development partner;
      - Government's attention on waste reduction and recycling acceleration potentials through D4R; and
      - Other projects—Sea the future for doubling recycling rates; matchmaking all efforts to create policy recommendations that can be accepted by all stakeholders; end-results: strict regulation vs voluntary guideline.
   b. Ms Gitafajar Saptyani, Project Manager of CAP-SEA, GIZ:

- Introduction of CAP-SEA project; objective: to reduce single-use plastics waste generation by innovative business models; implemented in 3 countries (Indonesia, Malaysia, Thailand);
- In Indonesia, CAP-SEA aims at contributing to marine litter reduction as Presidential Regulation 83/ 2018, also supporting waste reduction by producers as KLHK Regulation 75/ 2019; and
- CAP-SEA supports development guidelines and standards of economy circular products through conducting the D4R study, in cooperation with BINTARI Foundation, with expected outputs: applicable D4R criteria for Indonesia (adopting economy circular principles without sacrificing certain interests), D4R guidelines for selected packaging types, and policy recommendations.

2. Study Introduction and Results

   Presentation by Prof. Dr. Ir. Budi Widianarko, M.Sc (study team):

   - Meeting objectives: presenting survey results and recourse person consensus; receiving feedback from broader stakeholders; study's background and objectives: increasing circularity of 3 selected packaging types;
   - Study method—Delphi: history (invented during the cold war; to quickly predict facilities that might be targeted by enemies); Delphi application in the study: gather stakeholder representatives as experts; conducted anonymously; done repetitively—allowing rejecting/ adopting new ideas until successfully form a consensus for the discussed issues (Round I: 14 Dec 2022–5 Jan 2023; Round II: 16–20 Jan 2023; Round III: 14 Feb 2023);
   - Resource persons for Delphi survey: 14 representatives of related ministries/ agencies, NGOs, universities, scavengers, packaging producers, manufacturers, and recyclers;
   - Survey questions: stakeholders and packaging type selection; and
   - Survey results on stakeholder part: related stakeholders along the packaging value chain and their interests—it is challenging to select only 3 prioritised packaging types and define criteria that could accommodate the various interests.

   Presentation by Moh. Nurhadi, S.T., M.Ling. (study team):

   - Selection process: from 10 packaging types (references from GIZ market study—conducted by Waste4Change), down to 3 packaging types; using expert judgement (qualitative method) and weighted criteria selection (quantitative method);
   - Justification criteria: hugeness of production scale, lowness of recycling rate, and willingness to adopt by producers (if D4R guideline is developed);
   - 3 selected packaging types: HDPE packaging for non-food products, LDPE packaging for non-food products, and PET bottles for mineral water;
   - Conflicting interests in D4R development: thickness, minimum volume, size of labels, seal and barrier necessities; and

- Discussion results of D4R criteria by Delphi resource persons; proposed D4R criteria by the study team (after analysing and literature review).

3. Feedbacks on the Study Results

   a. Mr Putut Pramono (Nestle, PRAISE): The density of the bottle and closure should be more than 1 g/ cm^3, so it can sink; on the contrary, the label should be less than 1 g/ cm^3, so it will be floating.

      Study team: Correct, we can use density for material separation—if we want to make it floating then the density can be designed less than water density. We will check the sign consistency.

   b. Ms Annie Wahyuni (Danone): Currently, not many HDPE bottles have embossed on them—usually, it uses paper/ plastic glued on the bottle; but, the adhesive contains harmful PVC; as result, the contaminated parts will be cut and it makes not be 100% recycled. PVC is also used in the seal and label; it disturbs the recycling process. I suggest removing paper and PVC from the D4R criteria.

      Also, how to read the assessment scale of PET?

      Study team: Thank you for the suggestions. For PET, it has a high recycling rate, so it is scaled low in our assessment. The D4R guideline aims at increasing the circularity of the material; therefore, a lower recycling rate will get a higher scale. The high recycling rate in PET also creates disagreement among resource persons (36%), regarding whether to include it as the prioritised material for D4R or not.

   c. Mr Donny Cossarizka (DOW): Shampoo bottles should be categorised as HDPE, not LDPE.

      Study team: We got a reference of the 10 popular packaging types from a previous study conducted by Waste4Change.

      Ms Kita Pritasari (Waste4Change): Based on our study on some producers' market reports and also direct checks on retailers-distributors, there is LDPE (rigid) packaging for non-food products in the market.

   d. Mr Rendra Hasan (CMMAI): Will PET be designed to sink, while HDPE-LDPE will be designed to float?

      Actually now, there is an effort to make all plastic packaging float when entering water bodies.

      Study team: For PET, the density is more than 1 g/ cm^3, so it will sink. The combination with other materials in the seal or closure will use PE/ PP/ other material that has a density of less than 1 g/ cm^3.

      Mr Putut Pramono (Nestle, PRAISE): Material separation using density is a common method in the mechanical recycling process. Hopefully, in the future D4R (criteria), all parts of packaging are made from the same materials, so no separation process is needed.

      Study team: During the Delphi process, the resource persons proposed monomaterial for packaging (if the bottle is PET, then the label and closure should

be PET also). However, after reviewing the literature, standards in other countries are not that strict. If it is too ideal, it could be hard to implement/ get less adoption by producers.

e. Mr Berry Padmanegara (PT Primajaya Eratama, INAPLAS): Suggest the D4R guideline is categorised based on material type: rigid and flexible, monolayer and multilayer, then also categorised (based on enforcement level): obligated to recycle and non-obligated. So, it could be implemented in all types of converting (companies). There are many brand owners, for example Coca-Cola, already have global initiatives to use 100% recycled resins for certain parts.

   Study team: We got similar suggestions during the Delphi process, some resource persons suggested making the D4R very ideal and obligated, but the others have opposite suggestions. The study team tries to seek a middle ground. Besides that, we also need to think about compliance; therefore, we start with 3 prioritised packaging.

f. Ms Ida Syuhada (BRIN-PRTP): Are there any considerations for including rigid packaging only? Is the consumption statistically higher? Is there any data for the flexible packaging recycling rate?

   Study team: When we choose rigid materials, it does not mean we leave flexible materials aside. We should see it in stages; starting from the ones easy to manage and closer to increasing the recycling rate, to ensure the implementation. Rigid materials are considered as more simple than flexible packaging. They have been collected for recycling. Their post-consumption packaging collection is expected to increase by introducing D4R. On the other hand, flexible packaging is more complex and needs more time and energy to shift to easier-to-recycle packaging. So, it is to grab the low-hanging fruits by starting with rigid plastics.

   It is also hard to get the data—so far, we only get data based on polymer types, not until their functions, and not comparable since they have different scales.

g. Ms Inezia Aurelia (Siegwerk, IPRO): I am from an ink company. For non-food packaging, the ink is not about being toxic or non-toxic, but it should be able to be de-inked (washable). Also, if no ink is allowed, this could be bad for ink companies.

   Study team: The criteria of non-toxic and washable could be complementary (taking into account the wastewater). This stakeholder consultation aims to find win-win solutions for easy-to-recycle packaging that meet all stakeholder interests. It is not to ban the use of ink, but to trigger the use of ink that is not conflicting with recycling purposes (what ink, where and how to apply).

h. Ms Desy Rasta Waty (BPOM): Are all these 3 selected packaging will have D4R guidelines?

   Study team: All of them will be proposed. Actually, we also have initial results for other packaging types, but not elaborated further.

4. FGD

   a. Regulator Group Discussions—facilitated by Prof. Dr. Ir. Budi Widianarko, M.Sc (study team):

- The D4R guidelines can serve as a stepping stone towards compliance with government regulation on waste recycling, e.g. extended producer responsibility (EPR); however, it should have some level of enforcement by incorporating some form of 'command-and-control' traits;
- While the D4R guidelines should ideally be voluntary in nature, it is important to implement them step-by-step, following a clearly defined roadmap that leads to the adoption of the ideal criteria of design for recycling. This will ensure that the transition towards compliance;
- A regulatory impact analysis needs to be done prior to the implementation of the D4R guidelines, especially on the costs to be shouldered by the producers which will ultimately be passed on to the consumers; and
- There is a need for devising an incentive system to stimulate the adoption of the D4R guidelines by the actors, esp. SMEs.

b. Upstream Stakeholder Group Discussions—facilitated by Moh. Nurhadi, S.T., M.Ling. (study team):

- The type of material does not have to be a monolayer. Multilayer with monomaterial is still easy to recycle. The colours of the materials are preferably transparent or white. However, light colour material is tolerable or not conflicting with recycling requirements;
- The minimum size of the bottle is essential to recommend to find a win-win solution between the interests of producers and recyclers. Currently, PET bottle sizes are very diverse and without minimum size restrictions. Brand owners produce small sizes (150 mm or less) to meet consumer convenience. However, small-size bottles create difficulties in collection. Waste collectors are not interested in collecting light bottles. The group suggested reducing the suggested criteria (600 ml for PET and 250 ml for non-food HDPE and LDPE); and
- Additives and barriers are still necessary for all types of packaging. The plastic manufacturer applies additives to make the injection process easier while the producers/ brand owners expect that there is no contamination from packaging to products, either from external exposure, or molecule migration. The knowledge of conflicting additives and barriers among the participants as well as among the recyclers is limited. The researchers need to explore literature or other research; and
- Some criteria might increase the production cost: laser marker, water based ink, and soluble adhesive. It can influence the production cost and product prices and reduce competitiveness especially to small and medium industries (however, actually the price or cost can decrease when the use of water based ink and soluble adhesive increases/ or becomes commonly used). Therefore, it needs incentives/ subsidies or other mitigation policies.

c. Downstream Stakeholder Group Discussions—facilitated by Kristanto Irawan Putra, B.Sc (study team):

- The group discussed packaging volume/ bottle size intensively. The representative of ASPADIN suggested 250 ml as the minimum volume with the

argument of consumers' practical needs, market attractiveness, and avoiding water leftover in the bottle. However, it encountered by the representatives of APSI, Langgeng Jaya Group, Polindo Utama and ASOBSI with the reasoning: (i) small volume/ size is not attractive for collection, esp. in the rural area; (ii) similar efforts given in bottle segregation and collection (regardless of the size), yet would obtain less yield; and (iii) small bottle size creates difficulty in pressing and resulted in poor quality of recycling outputs. The group agreed on proposing a minimum volume of 600 ml for bottle size; or, it could be smaller but should have the same weight as the current 600 ml bottle (for PET mineral water bottle, it refers to Aqua/ Le Minerale bottle weight). This suggestion is lower than the KLHK Regulation 75/ 2019 requirement—the minimum size is 1.000 ml;

- Some discussions on other criteria. **Colour**: the group agreed that the bottle colour preference for recycling process easiness is (i) clear; (ii) white; (iii) light colour; and (iv) black/ dark colour. **Label**: the recycling of PVC film (PET bottle's label) is technology-feasible, but not business-feasible. However, the usage of PVC film is judged better than sticker-based/ paper-based labels which will leave adhesives/ contaminants in the recycling process. **Seal**: the clear PVC film on the cap needs to be phased out. In most cases of recycling, the left-over and unseen condition of the clear PVC seal will impure the cap's material;
- For increasing producers' adoption of D4R guidelines, the group proposed for the government to introduce plastic credit regulation. The producers not following the guideline (e.g. producing small bottles), should give financial support to incentify the packaging collection. This incentive will be used for waste transportation and initial processes (washing, etc). As an example, IPRO members have been subsidising IDR 1.000 per kg of waste collected in some areas in East Java, Bali, and Lombok, even though only for a certain period/project-based, not continuously; and
- [Beyond D4R topic] More support is needed to nurture the recycling industries in Indonesia, e.g. limiting the import of recycling materials, and banning the export of post-consumption bottles.

5. Plenary: Group Presentations and Stakeholder Feedback
   a. Regulator Group Presentation

      Presented by Mr Rendra Hasan (CMMAI):

      - Impacts of D4R criteria on stakeholders: incremental costs for producers, brand images;
      - Some considerations for deciding D4R implementation: mandatory vs voluntary; an idea of 'controlled' voluntary *(voluntary 'terpimpin')*; and
      - If voluntary, it needs legal certainty for the market; needs to enable the market. Some ideas for voluntary: EPR scheme development, non-fiscal incentives (MoI's certifications, KLHK's PROPER award); it might be mandatory if some prerequisites are fulfilled, e.g. mitigation for producers' incremental costs.

      Feedback:

      - Producer's representative: What about fiscal incentives?

Mr Rendra Hasan (CMMAI): PROPER is related to the bank process (minimum blue level for having cooperation with banks). By regulations, every party that produces waste is obligated to reduce and manage their waste; procedures have responsibility (for handling) the packaging that is hard to recycle. Incentives are used only for encouragement/ stimulus—our approach is effort sharing, instead of burden sharing. We have a study with GIZ about fiscal measures for waste reduction, e.g. EPR implementation, deposit refund system, green public procurement.

Mr Murboyudo Joyosuyono (MoI): MoI will tend to take industry sides; MoI will facilitate if there are suggestions for interesting incentives for industries. There is a directorate specifically for maintaining the business climate. However, so far there are no specific fiscal incentives for environmental efforts.

Mr Rendra Hasan (CMMAI): shared a story about unsuccessful fiscal incentives due to KPPU rejection since it is considered not good for business competition.

b. Upstream Stakeholder Group Presentation

Presented by Mr Putut Pramono (Nestle, PRAISE):

- Implementation challenges for SMEs; incremental cost for changing multilayer laminated to recyclable monomaterial is around 5%–25%. The D4R guideline will be a 'journey' for increasing the recycling rates in Indonesia;
- The difference between food and non-food packaging is only in food safety, but there is no difference in the recycling context. The recycled packaging should be food-grade;
- Some inputs on the D4R criteria. For **bottle material**, it is more appropriate to be called monomaterial, rather than monolayer; ideally, white colour. **Barriers** are still needed for product protection; the absence of barriers could reduce the product's lifetime—it needs several months for distributing products to Eastern Indonesia. Similarly, some **additives** are still needed in the manufacturing process to achieve production efficiency. It needs clarification on the type and percentage amount (concentration) of barriers and additives that fulfil the recycling purposes. For **seal**, as long as it is not PVC; but, sometimes the problem is not the material itself, but the littering behaviour; and
- An additional point from Ms Inezia Aurelia (Siegwerk, IPRO): some inputs for the government, we need incentives, clearer definition (of eco-friendly packaging)—whether closed loop; and also whether the D4R implementation is mandatory.

Feedback:

- Mr Saut (APSI): Who produces the waste? The first sin goes to producers; the second sin goes to communities for littering behaviours. D4R (implementation for producers) and waste separation at home should be mandatory. The government should make a roadmap, test it in pilot areas, monitor the progress, and also enforce it by punishment; so the burden will be not only on the producers.

c. Downstream Stakeholder Group Discussions—presented by Mr Saut Marpaung (APSI):

- Appreciations for some brand owners that redesign their packaging from coloured to clear transparent bottles. On the other hand, the downstream stakeholders face an income decrease due to the bottles' thickness reduction. Hence, stakeholder consultations are mandatory for every policy change;
- A minimum volume of 600 ml is proposed for the D4R of PET bottles. The producers that still produce small bottles should give financial support to incentify the collection; and
- Clear PVC films on the closure need to be phased out.

Feedback:

- Ms Annie Wahyuni (Danone): Volume criteria may be not closely relevant for D4R; instead, multilayer and multi-material packaging are the problems;
- Mr Putut Pramono (Nestle, PRAISE): Reduction of virgin plastics usage becomes the goal of multinational brand producers. Furthermore, dimension optimisations (e.g. in volume, thickness, and weight) are the way to achieve cost competitiveness;
- Mr Saut (APSI): Nevertheless, the reduced income from the downstream stakeholders should also be taken into consideration;
- Ms Mela (Polindo): The reduction of bottles' weight will also threaten the quality of recycling materials; similar production cost given in the recycling process, yet would obtain less yield. The export banning of post-consumption bottles needs to be implemented;
- Ms Annie Wahyuni (Danone): The recycled content policy in Europe has encouraged the export of post-consumption bottles. This policy causes an increase in virgin plastics imports in Indonesia.

6. Stakeholder Consolidation Results

Facilitated by Moh. Nurhadi, S.T., M.Ling. (study team):

a. The study outputs will be used as inputs for the regulation; there will be more stakeholder consultation process to discuss the criteria before it is regulated; the study results are working document and need to be reviewed following the situations (e.g. technology development);
b. The criteria that potentially create incremental costs will be reviewed in the study report. Then, additional policies to mitigate/ minimise the impacts will be suggested (e.g. fiscal incentives);
c. There are some criteria already agreed upon by stakeholders, but also some criteria are still under discussion (e.g. minimum volume, laser marker for direct printing, barriers, and additives). The stakeholder consensus on D4R criteria:

   Body: monomaterial; white/ bright colour for HDPE-LDPE packaging; possibly other colours (in the limited to recycle criteria), but should not be black/ dark colour; no colour/ clear for PET mineral water bottles, and bluish (in the limited to recycle criteria); no consensus on minimum **volume**;

Barriers and **additives** are still needed; for HDPE-LDPE packaging, need more references on the possible barrier and additives types, as well as concentrations that will not disturb the recycling process; for PET mineral water bottles, will be used the existing BPOM standard;

The **closures** should show polymer type logo (as MoI Regulation 24/ 2010) and made from PE material; utilisation of PP material for the closures is still allowed (in the limited to recycle criteria), but not PS, PVC, PLA, or aluminium; closure has clear/ white colour, possibly non-opaque bright colour (in the limited to recycle criteria), but should not be black/ dark colour;

No **seal** for HDPE packaging, or should be attached to the closure; PP, PET, or PETG are allowed (in the limited to recycle criteria), but not PS, PVC, PLA, or aluminium; for PET mineral water bottles no film seal, or using ring seal with the same material as the closure (or other seal design as long as it serves the function of un-opened product evidence);

The **label** uses HDPE, LDPE, LLDPE, MDPE, or PP, with less than 50% coverage; not allowed using paper, PET, PETG, PS, PVC, PLA, or aluminium;

The **ink** should be washable, water-based, and non-toxic; or only non-toxic (in the limited to recycle criteria); **direct printing** uses laser marker or flexo for production date and best before; emboss for material type and recycling logo;

Other components (e.g. rubber seals, spiral wires) are allowed as long as they are easy to be removed and have economical value for the collectors.

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