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Knowledge Sharing Program

2021/22 KSP Policy Consultation Report

Ecuador II

Efficient Production Technology, Methods and Innovative Machinery for Recycled Products Based on Expanded Polystyrene and Polypropylene

Ministry of Economy and Finance

kotra Korea Trade-Investment Promotion Agency

SEOULTECH SEOUL NATIONAL UNIVERSITY OF SCIENCE & TECHNOLOGY

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Prepared for	The Republic of Ecuador
In Cooperation with	Ministry of Production, Foreign Trade, Investment, and Fisheries

Supported by	Ministry of Economy and Finance (MOEF), Republic of Korea
Prepared by	KOTRA(Korea Trade-Investment Promotion Agency)
Project Director	Chulho Park, Director General, Development Cooperation Office, KOTRA
Project Manager	Sunghee Lee, Deputy Director, Development Cooperation Office, KOTRA
Project Officer	Hojin Lee, Assistant Manager, Development Cooperation Office, KOTRA
Senior Advisor	Bok-Hwan YU, Former Head of Presidential Committee on Green Growth
Principal Investigator	Chaegun Phae, Professor, Seoul National University of Science and Technology
Authors	Chapter 1. Jiwon Kim, Researcher, Hyundai Research Institute Hannah Park, Senior Researcher, Hyundai Research Institute Chapter 2. Sang-il Rhee, Senior Researcher, Hyundai Research Institute Hanee Ryu, Research Fellow, Hyundai Research Institute Chapter 3. Sangmin Lee, Researcher, Hyundai Research Institute Yongjung Park, Research Fellow, Hyundai Research Institute Chapter 4. Chaegun Phae, Professor, Seoul National University of Science and Technology Kyeong Kim, Senior Researcher, Seoul National University of Science and Technology Dowan Kim, Researcher, Seoul National University of Science and Technology Chapter 5. Chaegun Phae, Professor, Seoul National University of Science and Technology Dowan Kim, Researcher, Seoul National University of Science and Technology Chapter 6. Chaegun Phae, Professor, Seoul National University of Science and Technology Jongsoo Lee, Researcher, Seoul National University of Science and Technology Sunho Park, Researcher, Seoul National University of Science and Technology
English Editor	Korea e-Work Association for the Disabled

2021/22 KSP Policy Consultation Report

Efficient production technology, methods and innovative machinery for Recycled products based on Expanded Polystyrene and Polypropylene

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ACRONYMS

Abbreviation	Full Description
ABS	Acrylonitrile Butadiene Styrene
AI	Artificial Intelligence
ASEPLAS	Asociación Ecuatoriana de Plásticos
BOPP	Biaxially Oriented Polypropylene
CEAP	Circular Economy Action Plan
CNOOC	China National Offshore Oil Corporation
CNPC	China National Petroleum Corporation
DSD	Duales System Deutschland GmbH
EPE	Expanded Polyethylene
EPP	Expanded Polypropylene
EPR	Extended Producer Responsibility
EPS	Expanded Polystyrene
EU	European Union
FW	Food Waste
HRI	Hyundai Research Institute
IoT	Internet of Things
JEPA	Japan Expanded Polystyrene Association
KOTRA	Korea Trade-Investment Promotion Agency
KSP	Knowledge Sharing Program
LG	Local Government
MPCEIP	Ministerio de Producción, Comercio Exterior, Inversiones y Pesca
MR	Material recycling
MSW	Municipal Solid Waste
NPC	National People's Congress
OECD	Organisation for Economic Co-operation and Development
PE	Polyethylene
PE-HD	High-Density Polyethylene

ACRONYMS

Abbreviation	Full Description
PE-LD	Low-Density Polyethylene
PE-LLD	Linear Low-Density Polyethylene
PE-MD	Medium-Density Polyethylene
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PSP	Polystyrene Paper
PVC	Polyvinyl Chloride
RCC	Rotary Chain Crusher
RFID	Radio-Frequency Identification
RW	Recyclable Waste
SME	Small and Medium-sized Enterprise
SNUT	Seoul National University of Science and Technology
SUIA	Sistema Único de Información Ambiental
SUP	Single-Use Plastic
UMS	Urban Mining Solutions GmbH
VBW	Volume Based Waste
WTO	World Trade Organization
XPS	Extruded Polystyrene

Summary

Summary

This report aims to share the knowledge and experience of the Korean government to guide Ecuador. The purpose of this report is to have the Ecuadorian government devise new policies based on the results of the project and develop existing policies to contribute to economic development.

In Chapter 1, “Introduction” described the background, purpose of the study, and the overall method. Ecuador recently wanted to foster the plastic industry, however difficulties in supplying raw materials for plastic made the government to increase its interest on recycled raw materials. In this situation, the country wanted to get solutions for EPS and PP which had more hardship on getting recycled than PET and PE materials. Accordingly, this report comprehensively analyzed Ecuador’s plastic-related status, other country cases, and Korea’s experience, focusing on EPS and PP plastic, and presented resource circulation models necessary for Ecuador, roadmaps and follow-up projects as well.

In Chapter 2, “Global Plastic Waste Management Trends and Country Cases” examined the trends of global discussions on plastic waste management scheme. Germany, Japan and China were selected as major countries to investigate plastic-related industries, laws, policies and recycling technologies. In the case of Germany, the country has been leading the waste treatment and recycling field among OECD countries since the 1990s and has had many implications in terms of law and system. In addition, Germany is leading discussions on the global circular economy scheme, including the EU’s plastic waste-related strategies, and is leading countries to implement waste reduction plans and market regulations. In the case of Japan, the country is an unrivaled country in the field of incineration with energy recovery among waste treatment methods. Moreover, Japan has organized waste-related laws and systems from an early stage. In particular, Japan’s laws and systems regarding their local level micro-management of plastic waste management and resource circulation strategies had many implications. Finally in case of China, their ban on waste imports from

2018 brought shock to the global waste market. In addition, it was confirmed that laws and regulations regarding waste management have been strengthened in the country since relatively recently.

[Table 1-1] Summary of Global Waste Management Trends and Country Cases

Category	Contents
Germany	- Current Status of German Plastic Waste Management • **Germany is the leading country among OECD countries** • **Germany is in the highest position of global recycling rate in 2019 OECD stats** • **German's treatment consists of Recycling (48%), Incineration with energy recovery (31.6%), Compositing (18.7%) and Zero Landfill** • **Germany is also leading the plastic recycling scheme in the world¡** - Law and Policy • Law and policy focusing on 'Waste management' Waste Disposal Act (1972) : To control the prevalence of uncontrolled waste and take control of wastes by regional and local government New Waste Avoidance and Management Act (1986) : Promote recycling and lay the foundations for the scheme The Green Dot (1991) : World's first ever dual recycling system by imposing duties on both consumers and producers • Law and policy focusing on 'Packaging Issues' German Packaging Ordinance (1991) : Promote recycling and recovery of sales packaging New Packaging Law (2021) : Special concern to ban the distribution of lightweight plastic bags • German also in lines with EU's recycling scheme Circular Economy Action Plan (2015) : Aiming to transition from a linear to circular economy EU Plastic Strategy (2018) : As part of CEAP, more specified strategy for regulating the consumptions of plastic
Japan	- Current Status of Japan Plastic Waste Management • Japan is above average of total quantity of waste treatment and recycling from 1990s among OECD countries • Japan is in the highest position of incineration with energy recovery rate in 2019 OECD stats • Japan's treatment consists of Recycling (19.2%), Incineration with energy recovery (74.9%) / with out energy recovery (4.7%) and Zero Landfill • Japan has the largest share in the distribution of patented inventions for plastic prevention and recycling - Law and Policy • Two fundamental laws were established :Basic Law for Environmental Pollution Control (1967) and Nature Conservation Laws (1972) • Major laws and policies Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging (2000) : Production reduction and recycling have mainly been handled through voluntary agreements Basic Act on Establishing a Sound Material-Cycle Society (2000) : To reduce the use of natural resources and the load on the environment with the reduction, reuse and recycled method Act on Promotion of Resource Circulation for Plastics (2021) : To strengthen the plastic resource circulation system

Category	Contents
China	- Current Status of Japan Plastic Waste Management • China is above average of total quantity of waste treatment compared with OECD average • China's waste treatment is now on the turning point from conventional method to more environmentally friendly way • China's treatment consists of Recycling (30%), Incineration with or without energy recovery (31%), Disposal (7%), and Landfill (32%) • China has announced its ban on importing 24 kinds of solid waste including plastic waste and this decision affected the global plastic supply chain - Law and Policy • Solid Waste Act (2020) Series of obligations on waste generations Sets legal basis for bans on waste imports and single-use plastics Increases monetary penalties for noncompliance and violations Reinforces waste generators' monitoring system and responsibility • Proposal for Reinforcement of Plastic Pollution Management (2021) Ban on plastic food containers and plastic cotton swabs Ban on chemical products containing microplastics Set goals for reducing the rate of landfilled plas

In Chapter 3, "Status of Plastic Waste Management in Ecuador" analyzed Ecuador's waste management system, related laws and the plastic industry. As a result, it was confirmed that Ecuador had their national production standards for waste collection but has not been actively implemented. In the case of waste treatment, Ecuador's local governments are treating waste with the proportion of landfills-temporary camps-open landfills. There has been discussions on closing open landfills, but they have not yet been conducted. Ecuador's recycling promotion policy has its foundation on the EPR system, but the system is currently applied only to specific wastes. Ecuador's waste management governance is being carried out in cooperation with the Ministry of Environment and the Ministry of Production, Trade, Investment, and Fisheries (MPCEIP) of Ecuador. Ecuador's two most representative laws and systems are "Law of Circular Economy" and "Organic Law for the Rationalization, Reuse and Reduction of Single-Use Plastics" and the two laws operate complementary to affect local governments in Ecuador.

[Table 1-2] Summary of Status of Waste Management in Ecuador

Category	Contents
Waste Management in Ecuador	- Solid Waste Collection and Disposal • Total Waste collection in Ecuador : 7,549,06 MT/Year • Solid Waste collected : 5,510,816 MT/Year • Plastic Waste generated: 628,233MT/Year accounts for 11.4% - Taxation Methods • Imposing tax on solid waste management is managed differently at each GADs • 53.6% of waste management tax are charged by electricity bill in Ecuador - Flow Chart of Solid Waste Management • Starts with local manufacturers → Disposable plastics are collected in garbage bags without separation → Garbage bags are collected and transported to landfills → Network of formal and informal businesses collect and transport waste to the Centro de Acopio → Centers recover solid waste than materials are purchased by recycling businesses → Companies resell to manufacturers again - Awareness and environment responsibility in Ecuador • people are very conscious about the responsibility for environment deterioration • Above 61% of Ecuadorian people classify any waste solid (organic, paper, plastic, metal, etc.) at homes
Analysis of the Plastic Industry in Ecuador	- - Solid Waste in Ecuador • In Ecuador, organic wastes account for 57% and plastic waste follows at 11.4% • Final disposal of solid wastes (glass, plastic, cardboard, metal, paper) are mostly end up at landfills, open dumpsites, or cells - Plastic Wastes by types in Guayaquil • PET recycling is highly developed since Incentives are available for PET • Household plastic(HDPE and LDPE) waste distribution accounts around 29% • Since the recycling sector is mainly driven by informal collectors, they select plastics that are highly demanded, better-paid, and in larger volumes - PP Management • Since there are no polypropylene producers in the country, most of them rely on imports • PP has been increased to use in plastics container or replace EPS mainly - EPS Management • In case of Guayaquil city, local government announced that manufacturer must meet the criteria regarding recycling and eco-friendly standard
Laws and Regulations of Plastic Industry	- Governance • National Waste Management Program 2010-2021 : To remove open landfills from all municipalities in the country • Organic Environment Code (COA) : COA promotes a healthy environment and natural rights protection • The Codigo Organánico de Organización Territory (Antonymy Decentralization-COOTAD) : Provides for solid waste management within its jurisdiction, including design plans and legislation of 221 local governments (GADS) - Laws and Regulations • Law of Circular Economy : To priorities for environmentally friendly design, reuse, repair, restoration, manufacturing, reduction, recycling, and energy recovery in terms of waste management • Organic Law for the Rationalization, Reuse and Reduction of Single-Use Plastics : Regulation of the reuse and recycling of waste through the generation of plastic waste, the gradual reduction of disposable plastics, and responsible consumption of waste

In Chapter 4 “Korean case study”, introduced the history and system of waste-related laws in Korea, the main contents and effects of each law, the overall waste treatment process, and the EPS and PP recycling system. Considering the problems of Ecuador, systematically, the volume-based system, EPR, and waste charge system, and technically, a separate discharge station, a sorting facility, and EPS and PP recycling facilities were mainly introduced.

[Table 1-3] Summary of Korean Case Study

Category	Contents
Policy and Law	- Organic • Framework Act on Resource Circulation (2018) - Recycling • Act on the promotion of saving and recycling of resources(1992) • Construction waste recycling promotion act(2003) • Act on promotion of Purchasing of Green products(2005) • Act on resource circulation of electrical and electronic equipment and vehicles(2007) - Disposal
	• Waste control act(1986) • Act on Promotion of Installation of Waste disposal Facilities and Support for Surrounding Areas, Etc.(1994) • Act on the transboundary movement of hazardous wastes and their disposal(1995)
Processing and recycling	- MSW(Responsibility to Public) • Classification of Waste(Volume based bag, Recyclable, Food waste) → Discharge(Volume-based fee(For disposal) or Seperate(recyclable waste, Food waste) → Collect and Storage → Transportation → Sort(only recyclable waste) → Recycling → Incineration → Final Disposal(landfill) - Business waste(Responsibility to Private) • Classification of Waste(Industrial waste, Construction waste, Designated waste (Hazardous waste, Medical Waste)) → Discharge(Report the discharge) → Transportation(Report the collector) → Recycling or Disposal (Report the process)
Korean experience with machinery and recycling models that optimize the process of obtaining raw materials	- Process • EPS ** Recovery → Sort(External matter removal) → Crush and Recycling(Lightweight concrete, coating material) → Reducing → Ingot → Extrusion → Pellet → Recycled Product* • PP * Recovery(Mixed plastic) → Sort(manual and automatic) → Press → Crush → Recycling(Pellet, Recycled product, waste oil derived fuel, Solid refuse fuel) - Machinery • EPS ** Fixed Mechanical reduction equipment(For Massive discharge source)* ** Mobile Mechanical reduction equipment(Vehicle, Scattered discharge source)* ** Chemical reduction equipment* • PP ** Recycling Station, IoT container(I-tainer), RE100* ** Sorting facility and Optical sorter* ** Recycling facility(Pelletizer, Pyrolyzer)*

In Chapter 5 “To-Be Model for transitioning to a Circular Economy”, Ecuador’s plastic recycling industry efficiency was set as the final goal, a resource circulation model was proposed for this purpose, and a roadmap for establishing this model was presented. In the proposed resource circulation model, a station discharge system was proposed to increase the amount of EPS and PP possible through a separate discharge system so that private recycling companies can take the initiative in recycling, and to minimize the cost required for recovery. In addition, eco-friendly design, economic support, and compulsory utilization measures were presented to facilitate recycling in the recycling stage. This plan takes into account the characteristics of Ecuador, which lacks funds but has a high influence on residents, and focuses on the problem of waste recovery, so it is judged to be a suitable model for the supply and demand of plastic raw materials and recycling of resources.

In the roadmap, the tasks to be carried out in five aspects (Fundrasing, Eco-design, Establishment of separate discharge, Establishment of the EPS/PP recycling system, Promotion of resource circulation) were presented in the medium-term period for building the above model. A summary is presented in the Table 4.

[Table 1-4] Project to Establishment for To-Be Model for Transitioning to a Circular Economy

Term	Project
Short-term	• Introduction of VBR, EPR and waste discharge system
	• Publish of Guidelines for separate discharge system
	• Introduction of the recycling station
	• Implementation of education on separate discharge and promotion, development of applications, and Obligatory separation of discharge
	• Establishment of standards for installation and operation of sorting and recycling facilities
	• Introduction of massive discharge reduction equipment
	• Development of quality standards for recycled materials
Mid-to-long term	• Introduction of regulations on the material structure of packaging materials
	• Introduction of EPS recycling facility
	• Introduction of sorting and recycling facilities
	• Obligatory use of recycled materials`
	• Promotion of green consumption

In Chapter 6 “Linked Project Proposal”, suggests follow-up projects to establish a circular model, and are summarized in the table below.

[Table 1-5] Summary of Linked Project Proposal

Project	Contents
Enactment the law for waste management	- Definition of waste, responsibility for disposal, and regulations requiring separate discharge, Etc. - OECD waste classification system survey and Ecuadorian waste classification system development - Waste treatment type coding (Korea benchmarking) - Introduction of the waste treatment industry licensing system
Establish waste statistics	- Calculation of total waste generation and composition by investigation (treatment facility) - Calculation of the amount of waste generated by the establishment of an electronic handover system for workplace waste (discharger/collector/handler) - Ecuadorian waste generation and treatment status statistics
introduction of the EPR system for packaging materials and product	- Establishment and investigation of criteria for those subject to Obligatory introduction of EPR - Establishment of EPR operation system, such as the establishment of mutual aid association
Optimization and area-wide waste disposal process	- Identification of the status of public and private waste treatment facilities and review of optimization index - Adjustment of optimization index for each treatment facility by region - Separation discharge base and waste treatment facilities and facilities new installation and introduction demand
introducing a recycling station	- Implementation of pilot project and supplementation - Establishment of a supply plan (in the city center, priority supply to mass-generating sources, supply to small-scale sources)
Education for Separate discharge	- Development of separate discharge education content and publication and distribution of guidelines - Establishment of an education promotion plan for the whole nation (broadcasting, classes, public relations, etc.) - Separate discharge guidance and monitoring
Regulation of packaging material and structure	- Provision of regulations on the structure of recycled materials for each packaging material (benchmarking Korea) - Establishment of material structure evaluation system and preparation of operation plan
Standard of Obligatory use PCM and Development of quality standard	- Development of quality standards for Ecuadorian EPS and PP recycled materials - Introduction of certification according to ISO 14021 and establishment of the certification system
Installation of Recycling Facility	- Implementation of pilot project and supplementation - Establishment of a supply plan (in the city center, priority supply to mass-generating sources, supply to small-scale sources)

01

CHAPTER

Introduction

1. Project Background and Objectives

Introduction

1. Project Background and Objectives

1.1 Project Background

The 2020/21 Knowledge Sharing Program (KSP) with Ecuador aims to share the knowledge and experience of the Korean government to guide The Government of Ecuador in devising new policies and increasing the efficiency of its existing ones to boost its economic growth and development in specific sectors of the economy. The Ecuadorian government established National Development Plan named "Toda una Vida (2017–2021)". In the Plan, the government aimed to increase the share of total solid waste renewables from 17% in 2016 to 35% in 2021. The government recognizes plastic recycling as an important task in transiting to a circular economy and seeks ways to expand its recycling industry.

The Ecuadorian government is promoting an industrial upgrading policy to shift the industrial structure centered on agriculture and fisheries and the primary industry, which is highly dependent on crude oil, to the manufacturing industry. To this end, nine strategic industries were selected, and the plastic industry was included.

The Ministry of Production, Foreign Trade, Investment, and Fisheries, which oversees Ecuador's plastic recycling policy, emphasized the importance of the KSP project, noting that it is urgent to promote the recycling process and increase efficiency. The policy recommendations derived from the KSP project will be utilized to establish (i) recycling strategies to promote the recycling industry, (ii) a long-term plan from a legal and regulatory perspective and (iii) policy recommendations to apply optimized recycling technology and equipment.

The Seoul National University of Science and Technology and Hyundai Research

Institute (SNUT-HRI) consortium has experience in the field of systems and technologies for promoting plastic recycling, has expertise in tote legislation, and has conducted several KSP projects. Accordingly, KOTRA and the SNUT-HRI consortium will make practical and effective policy recommendations to the Ecuador government during the KSP Consulting Project period from December 2021 to July 2022.

1.2 Project Objectives

This project aimed to provide recommendations and suggestions helpful in establishing a robust system to develop the recycling industry in Ecuador based on Korean experiences. The KSP research team will conduct the study:

analysis of the current situation in Ecuador

The market of plastic production and commercialization: the import of raw materials, national supply, and export of final products.

The structure of the recycling market for production, sales, consumption, and processes of recycling of expanded polystyrene (EPS) and polypropylene (PP) in Ecuador.

sharing the Korean experiences of plastic recycling models, particularly EPS and PP

including other advanced cases in developed countries.

finding areas (technology, process, machinery, etc.) of the Ecuadorian plastic recycling industry to enhance competitiveness, and

establishing a mid- to long-term development strategy for developing the plastic recycling industry in Ecuador.

Hence, the objectives of KSP are as follows:

to provide practical and comprehensive policy consultations based on Korean development experience and put forth concrete recommendations on applying evidence-based knowledge to create customized policy solutions,

to enhance government officials' capacity to manage, establish, and build institutions in policy-related areas via various consultative activities to facilitate the implementation of the KSP policy recommendations, and

to foster mutually beneficial relationships through tangible and functional approaches to support the partner countries' efforts for economic development.

<Figure 1-1> Marco del Proyecto

02

CHAPTER

Global Waste Management Trends and Country Cases

Global Waste Management Trends and Country Cases

1. Global Plastic Waste Management Trends

Before discussing the global plastic waste management issue, it is important to look at the global solid waste management scheme. Total waste generation is consistently increasing worldwide because of population and economic growth. According to OECD, municipal solid waste generation increased mostly during the 1990s. Then, from the 2000s, municipal solid waste generation growth slowed with the changes in urbanization rates, income levels, consumption patterns, and national waste management practices. Especially, many OECD countries have introduced recycling targets and monitoring progress to manage the solid waste produced. Moreover, emphasis was made on manufacturers and importers to take responsibility for their contribution to waste creation through "Extended Producer Responsibility (EPR)". As a result, municipal solid waste landfilled in the OECD countries, which is the primitive form of waste management, has decreased from 54% to 41% between 2000 and 2020. Waste recovery has been shifted to recycling, incineration with energy, and other advanced forms. [1]

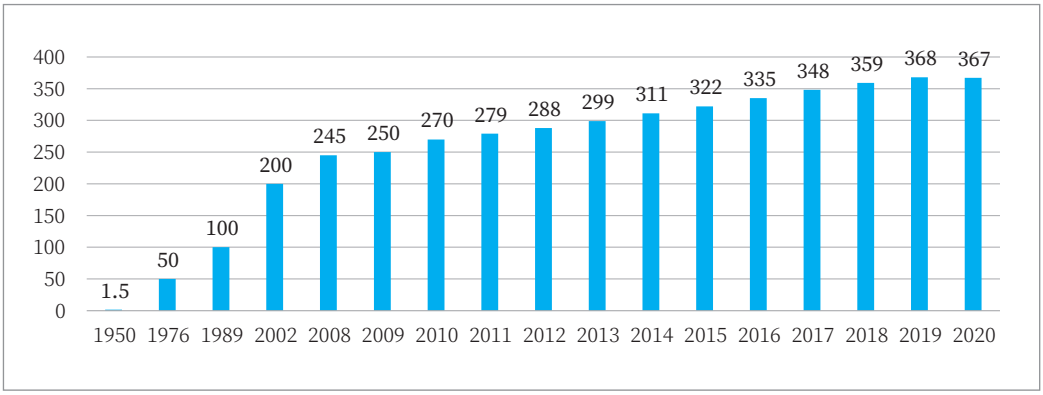
The global plastic waste management issue has become more prominent due to the drastic increase in plastic usage worldwide. Before the 1970s, the amount of plastic production was small, so plastic waste was relatively manageable. However, global plastic production has increased dramatically alongside the plastic waste generation boom after the 1970s. It is shown that plastic waste generation increased more in the last decade than it had in the previous 40 years. Plastic generation was estimated at 367 million metric tonnes in 2020, and its generation more than doubled from 2000 to 2019 to 368 million tonnes. However, only 9% of plastic waste is recycled, 19% is incinerated, 50% is dumped in landfill, and 22% is disposed of and goes into uncontrolled dumpsites, which are open pits

1 Municipal waste, generation and treatment. (2022). Retrieved Aug 08, 2022, from https://stats.oecd.org/viewhtml.aspx?dataset-code=MUNW&lang=en

and end up in terrestrial or aquatic ecosystems in developing countries. (OECD, 2019). The amount of mismanaged and littered plastic waste is increasing, reaching 82 million metric tonnes yearly. This low recycling rate negatively impacts humans, animals, and plants. Consequently, the global plastic recycling scheme is witnessing a significant growth trend, and many governments are increasing their concerns on plastic waste management with their consistent interest and support for plastic recycling issues. It is worth examining the case of some representative countries' waste management status and their laws and policies to deduce the implication of their actions on the encountered situations regarding plastic waste upsurge.

<Figure 2-1> Annual production of plastics worldwide from 1950 to 2020

(in million metric tonnes)



Source: Statista (2022)[2]

Germany has the highest recycling rate and advanced waste treatment system among the OECD countries. The OECD reports that Germany recycled 25,124,000 tonnes of waste in 2020, while the average amount of recycled waste was 2,827,000 tonnes. Since the implementation of the first Waste Disposal Act (AbfG) in 1972, Germany has been a leading country with innovative waste management systems, such as the Green Dot System, and has provided guidelines on the direction towards which the European Union should follow. Similarly, Japan has an above-average recycling rate among OECD countries, and its waste incineration facilities are particularly highly developed. As of 2019, 74.9% of municipal wastes were incinerated and treated in Waste-to-Energy facilities in Japan. Since the 1960s, Japan has continuously invested in sustainable waste management and recycling technologies as a country that has designed and adopted environmentally friendly programs and policies. While Germany and Japan have been consistently developing guidelines and regulations in such ways, China is the country that has recently had a substantial impact

2 Statista stat. (2022). Retrieved Aug 08, 2022, from https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

on the world waste treatment system and flow. Previously, China was the largest importer of municipal waste, but in 2018, it announced an import ban on 24 solid wastes, including plastics. This regulation significantly impacted the global plastics management and supply chain, and China has been increasing its efforts to regulate the amount of plastics since then. For the following reasons, this report will focus on the case studies of Germany, Japan, and China and provide a detailed explanation of their development history regarding waste management. [3]

2. Germany

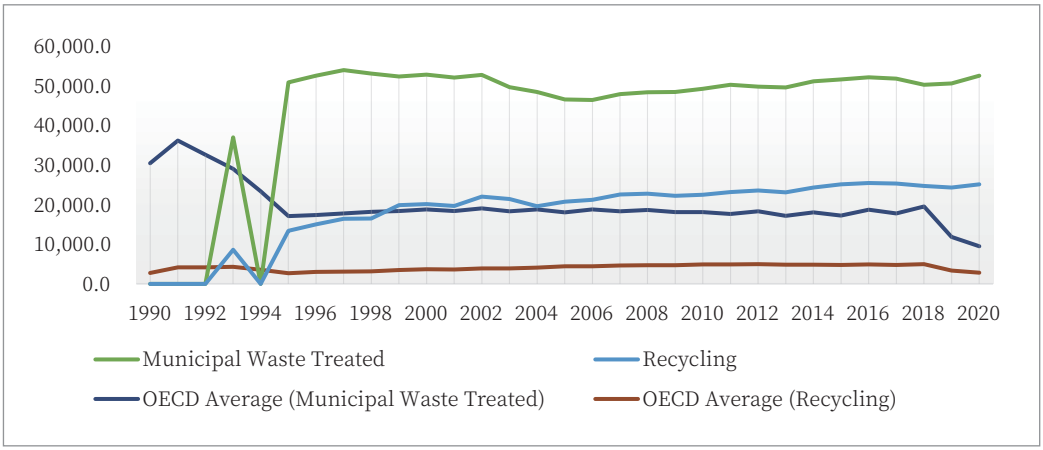
2.1 Plastic Industry

Germany's solid waste treatment and recycling figures are the most outstanding among OECD countries. According to OECD statistics regarding "Municipal waste, Generation and Treatment," Germany is the leading country in advance of both municipal waste treatment and recycling. Since the mid-1990s, Germany has been far above the average of both OECD figures until now. In 2020, Germany treated 52,567 tonnes of municipal waste, while average OECD countries treated 9,492 tonnes. Regarding recycling, 25,124 tonnes of waste were recycled in Germany, while OECD countries recycle 2,827 tonnes annually.

Moreover, Germany also holds a dominant position in recycling in its quantity and recycling rate. Germany was in the highest position on the global recycling rates list in 2019, except for South Korea and Slovenia. Germany's treatment operation of municipal waste consists of recycling (48%), incineration with energy recovery (31.6%), composting (18.7%), and 0% landfill. This means that most of the waste generated in Germany has been treated more efficiently and sustainably than conventional methods.

3 OECD. (2022). Environment at a glance indicators doi:https://doi.org/https://doi.org/10.1787/ac4b8b89-en

<Figure 2-2> Municipal waste treatment and recycling (1990–2020)



Source: Statista (2022)[4]

Among Germany's leading waste management performance, the country also leads the plastic recycling schemes in the world. The European Union, which holds a large portion of the global plastic recycling industry, will hold around 8.5 million tonnes of existing plastic recycling capacity by 2020. Out of the EU's existing capacity, Germany holds a recycling capacity of 1.5 million tonnes, which is almost 18% of the EU's total capacity.

Germany's unrivaled performance in waste management and recycling results from the government's long-term effort to improve the foundation for the recycling system. Since Germany's first Waste Disposal Act (AbfG), the government has made various actions applicable to consumers and producers. Later, Green Dot, the first ever duel recycling system in the world for collecting waste from consumers and producers, and following acts for waste management have evolved into a more integrated form of promoting a circular economy. Moreover, as the leading country in the EU, Germany is also involved in planning the Circular Economy Action Plan.

2.2 Law and Policy

In 1972, Germany implemented the AbfG to control the prevalence of uncontrolled refuse dumps and replace them with landfill sites that would be controlled and supervised by the regional and local governments. In 1986, the new Waste Avoidance and Management Act (KrWG) was introduced to promote recycling and lay the foundations for the EPR schemes to reduce waste generation. Under the Waste Avoidance and Management Act of 1986, the German Packaging Ordinance (VerpackV) was created in 1991 to promote

4 Statista stat. (2022). Retrieved Aug 08, 2022, from https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

recycling and recovery of sales packaging. In 1996, the Closed Substance Cycle and Waste Management Act came into effect, which later transformed into the Circular Economy Act (Kreislaufwirtschaftsgesetz) in 2012. In 2019, the new Packaging Law (VerpackG) was created to replace the Packaging Ordinance of 1991. In 2021, Germany adopted the First Act to Amend the Packaging Act to ban the distribution of lightweight plastic bags at the point of sale of goods from January 2022.

The Green Dot (Grüner Punkt) system was proposed by the Dual System (Duales System Deutschland GmbH, DSD) of Germany. It came into effect in 1991 to indicate how the waste packaging should be categorized for recycling. Many EU countries have implemented it as the main waste management system to comply with Directive 94/62/EC. Once the manufacturers pay the license fee to DSD, they can add the Green Dot logo to their package, indicating that this package should be thrown away into a separate yellow bag (Gelber Sack), which would later be collected by the DSD waste collection vehicles. Since manufacturers must pay a higher fee when they use more packaging, this system has successfully contributed to reducing the use of packaging. The DSD demands that private sector companies sign a contract with public-municipal waste management companies to properly recycle the waste packaging generated by end-users, and end-users are required to dispose of waste using six different recycling bins classified according to a color system. Moreover, the recycling plants of DSD are monitored and inspected by Technische Überwachungsvereine, or TÜVs, and the reports of incoming and outgoing materials are submitted to the government for review.[5] The specific policies of the German are presented in the Table 2-1.

[Table 2-1] Specific Policies of the German Plastic Strategy

Year	Laws and Policies
1972	Germany implemented the first Waste Disposal Act (AbfG).
1986	The new Waste Avoidance and Management Act (KrWG) was introduced.
1991	The German Packaging Ordinance (VerpackV) was created.
	The Green Dot (Grüner Punkt) system came into effect.
1996	The Closed Substance Cycle and Waste Management Act came into effect.
2012	The Closed Substance Cycle and Waste Management Act transformed into the Circular Economy Act (Kreislaufwirtschaftsgesetz).
2019	The new Packaging Law (VerpackG) was created.
2021	Germany adopted the First Act to Amend the Packaging Act.

5 European Environment Agency. (2021). Overview of national waste prevention programmes in europe - germany

Since Germany is the most influential country in the EU's recycling scheme influences, it is meaningful to look into the EU's law and policy. The EU is currently leading the global transition to a circular economy, and its strategies regarding treating plastic waste should be considered. In 2015, the European Commission adopted the first Circular Economy Action Plan (CEAP) to transition from a linear to a circular economy model. The plan mapped out 54 actions, including four legislative proposals on waste, and sets specific targets for landfill, reuse, and recycling to be achieved by 2030 and 2035. The Directive 2015/720 on Plastic Bags, in particular, was adopted to prevent and reduce the use of lightweight plastic carrier bags with a wall thickness below 50 microns. The Directive required EU member states to implement measures, such as national reduction targets, economic instruments, and marketing restrictions.

In January 2018, the European Commission adopted the EU Plastics Strategy as part of the CEAP to regulate plastic usage more comprehensively and contribute to achieving the 2030 Sustainable Development Goals. The EU Plastics Strategy includes the Directive on Single-Use Plastics (SUP), which prohibits using certain types of single-use plastics. The Directive came into effect in July 2021 and obliged EU member states to control national usage of single-use plastic items by implementing reduction measures, setting a separate recycling target, and necessitating labels and certain design elements for plastic products. The Directive also mentions EPR schemes, highlighting producers' responsibility in waste management and clean-up obligations.

Additionally, the European Commission amended Directive 94/62/EC, which has been applied since 1994, to Directive 2018/852 on Packaging and Packaging Waste, which included updated measures, such as implementing specific targets, EPR schemes for all packaging by 2024, and achieving a recycling target of 50% for plastic packaging by 2025 and 55% by 2030. In 2020, the European Commission updated the CEAP as part of the European Green Deal, the EU's new sustainable growth and development plan.[6,7]

[Table 2-2] Specific Policies of the EU Plastic Strategy

Specific policies	Background	Objectives
Bio-based, biodegradable, and compostable plastics	- No EU law in place applying to bio-based, biodegradable, and compostable plastics	- To promote the use of bio-based, biodegradable, and compostable plastics (forthcoming)
Global action on plastics	- No dedicated international instrument in place to prevent plastic pollution throughout the entire plastics lifecycle	- To set up an intergovernmental negotiating committee to close the gaps that existing instruments do not address

6 Park, S.Y., et al. (2021), Kwak, M.S., Jung, Y.S., Plastic-Free Policies of Major Eu Countries and Implication, KOTRA

7 Larissa Copello de Souza. (2019). Unfolding the single-use plastics directiveZero Waste Europe.

Specific policies	Background	Objectives
Microplastics	- No EU law that covers microplastics and no economic incentives for businesses to reduce the presence of microplastics	- To reduce the unintentional release of microplastics and ultimately reduce environmental pollution (forthcoming)
Plastic bags	- Amendment to the Packaging and Packaging Waste Directive (94/62/EC)	- To prevent and reduce the use of lightweight plastic carrier bags
Plastic packaging	- EU rules regulate the types of packaging and packaging waste allowed in the European market - Several revisions of the laws to include obligatory setting up of packaging EPR schemes and the addition of sustainable consumption reduction measures for plastic carrier bags	- To harmonize national measures on the packaging and the management of packaging waste - To prevent the production of packaging waste - To promote the reuse, recycling, and other forms of recovery of packaging wastes
Plastic waste shipments	- Implementation of the decision made at the 14th Conference of the Parties of the Basel Convention - New entries implemented in the EU Waste Shipment Regulation through Delegated Regulation (EU) 2020/2174	- To ban the export of plastic waste from the EU to non-OECD countries, except for clean plastic waste sent for recycling - To control the export of plastic waste from the EU to OECD countries and imports in the EU
Single-use plastics	- Rules to regulate the use of specific products - The ten items listed in the Directive include cotton bud sticks, food containers, cups for beverages, wet wipes, and sanitary items	- To prevent and reduce the impact of certain plastic products on the environment and human health - To promote the transition to a circular economy with innovative and sustainable business models, products, and materials

Source: European Commission.[8]

Regarding the shipment of plastic waste, the EU had already adopted the Waste Shipment Directive in 2006. The 14th Conference of the Parties to the Basel Convention in 2019 brought about necessary amendments, including the Delegated Regulation (EU) 2020/2174 on Plastic Waste Shipments. The European Commission implemented new rules on the export, import, and intra-EU shipment of plastic waste, which entered into force in January 2021. Currently, the EU is banned from exporting hazardous plastic wastes and those that are hard to recycle to non-OECD countries, and exporting clean, non-hazardous waste is allowed under specific conditions. To OECD countries, the export of hazardous plastic waste and non-recyclable plastics is subject to the "prior notification and consent procedure." Similarly, importing hazardous plastic waste from other countries to the EU and between EU countries is subject to the "prior notification and consent procedure."[9]

8 European commission. Retrieved Aug 08, 2022, from https://ec.europa.eu/environment/topics/plastics_en

9 OECD. (2022). Information about controls for transboundary movements of non-hazardous plastic waste OECD

[Table 2-3] Timeline of the laws and policies on the environment and recycling in the EU

Year	Laws and Policies
1994	The Directive 94/62/EC came into force.
2006	The Waste Shipment Directive entered into force.
2015	The first Circular Economy Action Plan (CEAP) was adopted by the European Commission.
	Directive 94/62/EC was amended to reduce the consumption of lightweight plastic carrier bags, and Directive 2015/720 on Plastic Bags was enforced.
2018	The EU Plastics Strategy was announced.
	Directive 94/62/EC was amended to promote the reuse and recycling of packaging waste, and Directive 2018/852 on Packaging and Packaging Waste came into force.
2019	The 14th Conference of the Parties to the Basel Conference was held in Geneva, Switzerland.
2020	The Delegated Regulation (EU) 2020/2174 was enforced.
	The European Commission adopted new rules on the export, import, and intra-EU shipment of plastic waste.
2021	The European Commission updated the CEAP as part of the European Green Deal.
	The Directive on Single-Use Plastics (SUP) (Directive EU 2019 2019/904) entered into force.

2.3 Recycling Technology

The main EPS and PP processing technology commonly used worldwide is chemical recycling. Through chemical recycling, plastic wastes are transformed into monomers or oligomers, polymerized, and turned into post-consumer recycled products. Currently, chemical recycling accounts for only 7% of the global plastic recycling industry, but it is expected that the use of chemical recycling will increase by an annual average of 17% until 2030. The EU, in particular, aims to increase the amount of recycling to above 55%, complying with Directive 2018/852 on Packaging and Packaging Waste.[10]

<Figure 2-3> Production of post-consumer recycled goods by reMarkable and Henkel

10 BASF. ChemCycling™. Retrieved Aug 08, 2022, from https://www.basf.com/kr/ko/who-we-are/ sustainability/we-drive-sustainable-solutions/circular-economy/mass-balance-approach/chemcycling.html

In Germany, a chemical company called BASF invests heavily in chemical recycling and creates plastic from the raw material extracted by pyrolysis of the recovered plastic. The company also started the ChemCycling™ project in 2018 to process pyrolysis oil derived from non-recyclable plastic waste.

① **EPS**

The EPC Group developed advanced EPS recycling technology with a coalition of German companies.

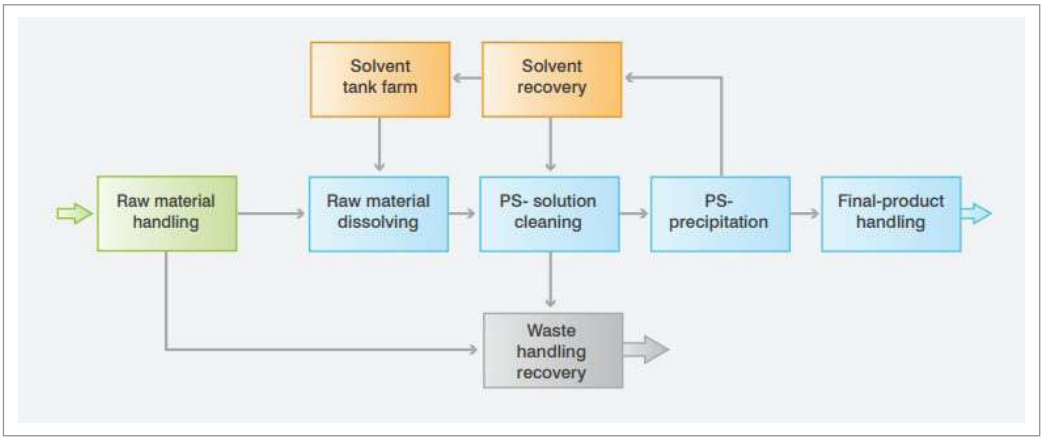
- Polystyrene loops are based on CreaSolv® technology (see Figure 2-4): Through the solvent-based purification processes (developed by Freunhofer IVV in partnership with CreaCycle GmbH), polystyrene can be separated from HBCD. HBCD treats bromine recovery units in ICL.
  - Step 1: Crush the collected EPS/PS waste
  - Step 2: Dissolve EPS/PS fragments using special CreaSolv®; only polystyrene is dissolved, so all other plastics and impurities remain solid in the slurry.
  - Step 3: Separate solid impurities from liquids.
  - Step 4: Separate PS gel from solvent (from PS under actual European limits of dissolved impurities like HBCD).
  - Step 5: Extrusion, selective filtration, and melting granules with high-quality recycled LED PS chips.

- In contrast to the current practice of incineration or landfill, an EPS recycling plant based on the CreaSolv® process is the first "closed-loop" recycling process for PS/EPS waste with or without hazardous impurities.

- Advantages
  - Alternatives to EPS combustion and landfill
  - Environmentally friendly process solution
  - High-efficiency solvent recovery—99% solvent recirculation
  - Option to transfer EPS from solution; reduction in transportation costs
  - EPC can use a "shelf" standardized plant design.
  - Possibility to convert almost any input stream configuration.[11]

11 EPC Group. EPS recycling technology. Retrieved Aug 08, 2022, from https://polystyreneloop.eu/wp-content/uploads/2020/03/flyer-eps_recycling_technology_creasolv.pdf

<Figure 2-4> CreaSolv® EPS recycling technology



② **PP**

Plastics collected in Germany are separated from ultra-modern sorting plants using various physical processes. Using infrared rays to recognize various packaging materials with reflected light spectra, plastic (PET, PE, and PS) is separated according to the type.

3. Japan

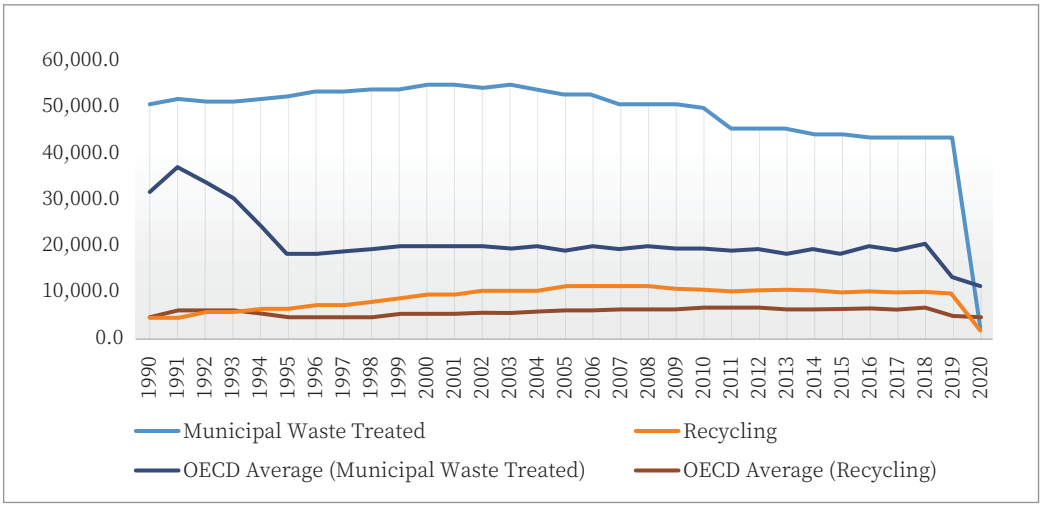
3.1 Plastic Industry

According to the Global Plastic Outlook (OECD), the global average recycling rate in 2019 was 15%, and Japan was named as an OECD country that reported an above-average recycling rate. In Japan, the amount of municipal waste recycled accounts for 19.2%, while 74.9% of the municipal waste is incinerated with energy recovery. Other methods, such as composting (0.4%) and incineration without energy recovery (4.7%), are not commonly used. In fact, Japan is a country with the world's leading waste incineration facilities and a highly developed industry for Waste to Energy (WtE) incineration. It has been reported that Japan has many small incinerators with an average capacity of approximately 60,000 tonnes (OECD, 2022). The heavy dependence on incineration can be observed in many OECD countries, including several Western European countries. This pattern is shown due to the incineration facilities' ability to handle large volumes of waste and the difficulties associated with constructing and maintaining sanitary landfills.[12, 13]

12 OECD (2022), Circular economy - waste and materials, in *Environment at a Glance Indicators, Paris*: OECD Publishing, https://doi.org/10.1787/f5670a8d-en.

13 OECD (2022), *Global Plastics Outlook: Economic Drivers*, Environmental Impacts and Policy Options, Paris: OECD Publishing, https://doi.org/10.1787/de747aef-en

<Figure 2-> Municipal waste treatment and recycling (1990–2020)

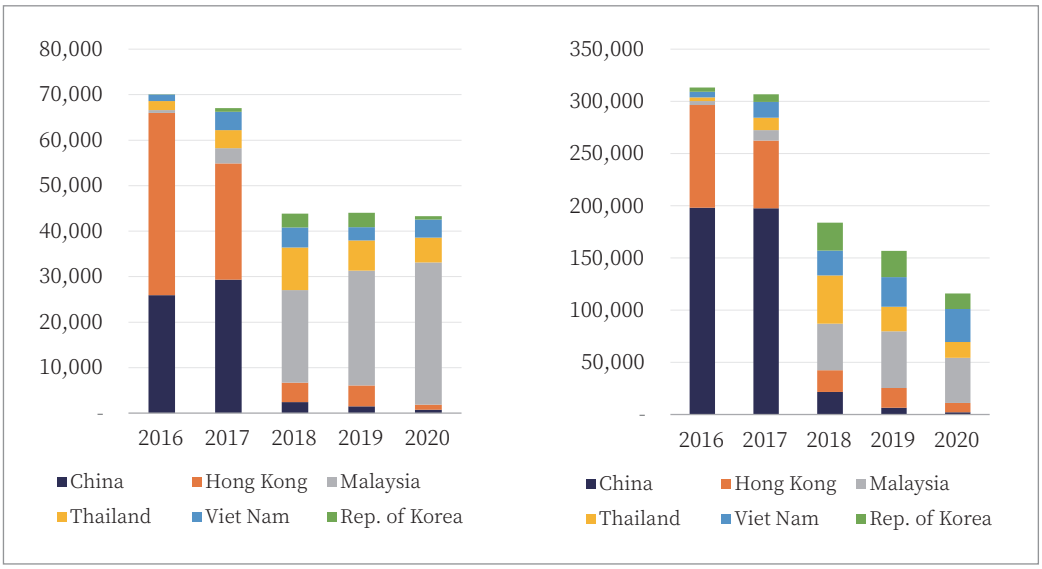


Source: OECD.stat (2022)[14]

Japan is a country that was largely influenced by the Chinese policy of forbidding plastic waste imports in 2018. Until 2017, Japan was one of the top plastic waste exporters, ranking behind the United States and Germany. The top destinations of Japanese waste plastics were China and Hong Kong because it was cheaper to export waste plastics to other countries than to manage them in Japan. However, due to the recent regulation, large amounts of plastic waste are stored in Japan. Some of these waste plastics are exported to Southeast Asian countries, such as Taiwan, Korea, Malaysia, Vietnam, and Thailand. However, the volume is generally small compared with what was previously exported to China.

14 OECD.stat. (2022). Retrieved Aug 08, 2022, from https://stats.oecd.org/viewhtml.aspx?datasetcode=MUNW&lang=en

<Figure 2-6> Export Trade Value HS 391520 (Waste EPS) and HS 391590 (Waste PP)



Source: OECD.stat (2022)[15]

Furthermore, Japan has the largest share in the distribution of patented inventions for plastics prevention and recycling, accounting for 31% of all plastics-related environmental patents. This means that the Japanese government, academics, and technicians have consistently been trying to manage waste more sustainably. At the government level, in particular, Japan has been designing and implementing national programs and policies related to environmental protection and recycling since the 1960s. In the past, the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging, the Basic Act on Establishing a Sound Material-Cycle Society, and the Act on Promotion of Resource Circulation for Plastics have all been adopted. As such, Japan is continuously investing in recycling and resource circulation technologies, such as safe municipal waste incineration technology and high-efficiency power generation, and is implementing related laws and policies to increase its waste management capacity and to administratively and financially support these efforts.[16]

3.2 Law and Policy

Japan introduced environmental laws relatively early, considering that its history of developing laws and policies related to the environment and recycling started in the 1960s. In 1967 and 1972, the two fundamental laws, the Basic Law for Environmental Pollution

15 OECD.stat. (2022). Retrieved Aug 08, 2022, from https://stats.oecd.org/viewhtml.aspx?datasetcode=MUNW&lang=en

16 OECD (2022), *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options*, Paris: OECD Publishing, https://doi.org/10.1787/de747aef-en.

Control and the Nature Conservation Law, were enacted, respectively. In 1993, the Basic Environment Law was enforced in realization of the seriousness of environmental pollution caused by mass production. Two years later, in 1995, the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging, which laid the foundation for the current Extended Producer Responsibility (EPR) system and the Japanese recycling system, was enforced to control and regulate the number of plastic products and promote a more eco-friendly society.[17, 18]

[Table 2-4] Timeline of the laws and policies on the environment and recycling in Japan

Year	Laws and Policies	
November 1993	The Basic Environment Law was put into force	
December 1995	The Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging (Containers and Packaging Recycling Act) was promulgated	
	1997	Started regulations that require producers except for small and medium-sized enterprises (SMEs) to recycle glass and PET bottles
	2000	The Containers and Packaging Recycling Act came into force with regulations that require all producers (except for those exempted) to recycle plastic and paper containers and packaging
	2006	Revision of the act, including the reduction of waste packaging
	2008	The revised Containers and Packaging Recycling Act came into force
	2016	Compiled the "Report on Evaluation and Examination of the Enforcement Status of the Containers and Packaging Recycling System"
	2018	Revised the rules for PET bottle recycling
June 2000	The Basic Act for Establishing a Sound Material-Cycle Society was put into force	
May 2019	The Resource Circulation Strategy for Plastics, based on the idea of "3R (Reduce, Reuse, Recycle) + Renewable," was adopted.	
January 2021	The Roadmap for Bioplastics Introduction was announced.	
June 2021	The House of Councilors passed the Act on Promotion of Resource Circulation for Plastics.	

- Containers and Packaging Recycling Act

Japan has systematically managed plastic waste with sorted collection and re-commercialization (recycling) under the Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging ("Containers and Packaging Recycling Act").

17 Inoue, Y. (2018), *Japan's Resource Circulation Policy for Plastics*, Ministry of Environment

18 Ministry of the Environment (2014), *History and Current State of Waste Management in Japan*, Japan Environmental Sanitation Center

Production reduction and recycling have mainly been handled through voluntary agreements; a plastic resource circulation strategy was created to respond to the international movements and take the lead in world trends. The Containers and Packaging Recycling Act was established in 1995. It was partially executed for bottles, cans, and PET bottles in 1997 and then expanded to include paper and plastic containers in 2000; this facilitated the reduction and recycling of household packaging waste.

The Act also specifies the type of producers subject to recycling obligations and requires these designated producers to adhere to the EPR system. According to the Act, the designated producers include those who use glass bottles, PET bottles, plastic packaging, or other paper packaging in their businesses and those who manufacture or import the packaging in the aforementioned categories. The application of the EPR system through this Act created obligations for the designated producers to recycle the waste packaging after being collected, replacing the previous government-led treatment of municipal solid waste (MSW). Under the Act, producers can recycle using three different types of methods: 1) sign a contract with the designated organization (the PRO) and pay commissions, 2) reuse or recycle the same containers and packaging they used or manufactured, or 3) collect waste packaging from municipalities and recycle or outsource them to a different organization.[19]

Accordingly, the responsibility of consumers, municipalities, and designated producers under the Containers and Packaging Recycling Act for the reduction of plastic products and recycling are given as the following:

- (Role of the consumer) Consumers reduce the production of waste with the intelligent selection of container packaging while separating and discarding container and packaging waste.
- (Role of municipalities) Municipalities must designate sorted collection plans and carry out measures necessary for the sorted collection of containers and packaging waste.
- (Role of designated producers) Businesses that manufacture or use targeted containers have a duty to re-commercialize and pay recycling fees to the Japan Containers and Packaging Recycling Association.[20]

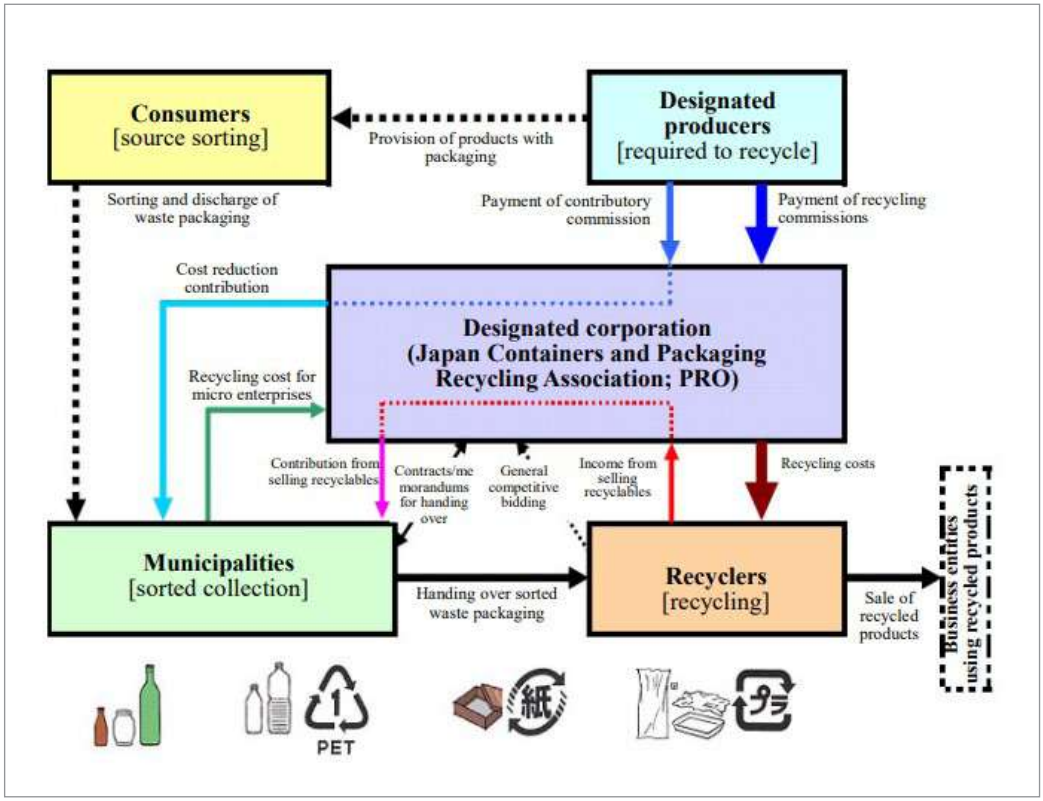
Figure 4 shows the material flow system by taking the recycling route with the PRO. Material markings became obligatory for sorted collection, and the legal system for creating

19 Yamakawa, H. (2016), "The EPR for packaging waste in Japan", in Extended Producer Responsibility: Updated Guidance for Efficient Waste Management, OECD Publishing, Paris, https://doi.org/10.1787/9789264256385-18-en. (accessed in March 2022)

20 Yamakawa, H. (2014), The packaging recycling act: the application of EPR to packaging policies in Japan, https://www.oecd.org/environment/waste/EPR_Japan_packagingFinal%20corrected0502.pdf

a cyclic society was completed in the early 2000s.

<Figure 2-7> Material Flow System under the Containers and Packaging Recycling Act



Source: Yamakawa, H. (2016)[21]

- Basic Act on Establishing a Sound Material-Cycle Society

Japan's legal system has different laws based on item characteristics with the Basic Act on Establishing a Sound Material-Cycle Society. The basis of the resource cycling strategy is 3R+Renewable. The goal is to reduce the use of natural resources and the load on the environment with the reduction, reuse, and recycled use of total material input, resource collection, waste output, and energy use.[22]

21 Yamakawa, H. (2016), *Outline of Material and Monetary Flows in the System Established by the Packaging Recycling Act* (PRO route) [image], OECD Publishing, Paris, https://doi.org/10.1787/9789264256385-18-en. (accessed in March 2022)

22 OECD (2019), Waste Management and the Circular Economy in Selected OECD Countries: Evidence from Environmental Performance Reviews, *OECD Environmental Performance Reviews*, Paris: OECD Publishing, https://doi.org/10.1787/9789264309395-en.

[Table 2-5] Overview of Japanese Plastic Recycling Strategy

Area	Vision (Milestone)
Waste reduction	By 2030, 25% output reduction with an accumulation system for disposable plastics (containers, packaging, etc.)
Reuse/recycling	Securing the reusability of plastic containers and packaging (while not affecting functionality) by 2025 with a redesign (even if this is difficult, heat recovery potential must be guaranteed) Recycling or reuse of 60% of plastic containers and packaging by 2030 By 2035, 100% utilization of all used plastic (inclusive of heat recovery)
Recycling/ biomass plastics	The goal is to achieve two times the current recycling rate by 2030. The goal is to introduce as many biomass plastics as possible (approx. 2 million tonnes) by 2030
Source: Ministry of the Environment of Japan (2019)[23]	

Recycling-related laws with clear goals for specific waste types, aimed at creating a recycling-oriented society, are being enforced, with the enactment of the Plastic Containers and Packaging Recycling Law (amended, 2006) being sought. There are regulations requiring consumers, local governments, and certain businesses to play their respective roles and try to reduce container and packaging waste. Approved methods for recycling plastic containers and packaging include mechanical recycling, reducing toxic substances using shaft furnaces, chemical fuel for coke, gasification, liquefaction, fuel, etc.

- Act on Promotion of Resource Circulation for Plastics

The Ministry of the Environment established the Act on Promotion of Resource Circulation for Plastics on June 4, 2021, to strengthen the plastic resource circulation system used for various items and facilitate resource circulation from the product design stage to the processing stage.

23 Ministry of the Environment (2019), Plastic Pollution and the Construction of Resource Circulation Systems for Plastics, in *Annual Report on the Environment in Japan 2019*, pp.16-20, Ministry of the Environment, https://www.env.go.jp/content/900457446.pdf

[Table 2-6] Specific Categories of the Japan Plastic Strategy

Category	Main contents	
Principle	National contribution to ecofriendly design for the control of plastic waste production and recycling— Creation of disposable plastic use standards Creation of measures for the separate collection, recovery, and recycling of plastic waste	
Policy Measures	Creation of eco-friendly design guidelines	• Establishment of eco-friendly design guidelines and creation of a system for certifying the suitability of designs • The nation is taking the lead in the activation of purchases of certified Recycled products • National support for recycling facilities
	Creation of disposable plastic use standards	• Creation of an action agenda for businesses that provide disposable plastics • Execution of recommendations, official announcements, and orders targeting businesses that provide large amounts of disposable plastic
	Creation of measures for the facilitation of separate collection and recycling for waste produced in municipalities	• Inducing the facilitated re-commercialization of plastic waste with the Containers and Packaging Recycling Act • If a plan between a municipality and a re-commercialization business has been approved, the municipal selection and packaging steps can be skipped for direction execution of re-commercialization
	Facilitation of voluntary waste recovery by manufacturers/sellers	• If manufacturers and sellers have created a plan for the voluntary recovery and re-commercialization of plastic products and it has been approved by a competent Minister, the licensing required by the waste disposal law can be skipped
	Facilitation of output reduction and recycling on the part of waste producers	• Creation of judgment standards regarding output reduction and recycling on the part of waste producers • Execution of recommendations, public announcements, and orders from a competent Minister regarding businesses with large volumes of plastic output • If a waste producer has created a recycling plan and the plan has been approved by a competent Minister, the licensing required by the waste disposal law may be omitted.

Source: Act on Promotion of Resource Circulation for Plastics

3.3 Recycling Technology

Recycling plastic for containers and packaging has been a policy in Japan since 2000, but the collected waste plastic varies significantly in type, form, and characteristics. Many problems were highlighted, such as pollution and mixing with foreign substances, so Japan's industrial technology has focused on fuel conversion and liquefaction. The Japan Plastic Recycle and Development Association has published a flowchart for the production, discarding, recycling, and disposal of plastic products in 2020. The amount of plastic waste used effectively with mechanical recycling, recycling for raw materials, and recycling for energy is increasing yearly.

There are 10.5 million tonnes of plastic resin in Japan, listed in order of decreasing production volume as PE, PP, PVC, and PS.

- The total amount of waste plastic produced is 8.22 million tonnes (4.10 million tonnes of ordinary waste and 4.13 million tonnes of industrial waste). Packaging and containers constitute 47% of the total output, while 60% of the total output comprises PE and PP.
- Out of the total waste plastic produced (8.22 million tonnes), 7.10 million tonnes are used effectively, whereas 1.12 million tonnes are unused and either buried or burned.
- A total of 1.73 million tonnes are processed with material recycling, 0.27 million tonnes with chemical recycling, and 5.09 million tonnes with thermal recycling. The main reason effective utilization increased is the greater use of solid fuel (refuse-derived fuel).[24]

① **EPS**

Most styrofoam is used only as containers and cushioning material in wholesale markets, supermarkets, department stores, restaurants, electronics stores, and equipment manufacturing plants. Recycling focuses on the processing of such business-related waste. Expanded polystyrene (EPS) has various everyday uses (depending on the product type) as containers for transporting fresh food, packaging for home appliances/OA devices, building insulation materials, etc.

Japan is creating a recovery system by collaborating with major producers, such as wholesale markets, home appliance businesses, and local governments.

- (Cooperation with wholesale markets) Recycling equipment, such as volume reduction machines, have been deployed (and efficient recycling is performed on site) for wholesale markets, which use large amounts of styrofoam as containers for fish tanks and other products. The Japan Expanded Polystyrene Association (JEPSA) aids in recycling by providing a partial subsidy for equipment installation costs when certain conditions are met.

- (Cooperation with local governments) Waste containers and packaging produced in the home are designated as general waste. This law stipulates the division of roles among consumers, local governments, and businesses and has implemented an efficient recycling system. Re-commercialization involves specific businesses' payments.

- (Styrofoam manufacturers and users) The same method is being used for the effective utilization of styrofoam waste produced in the home, and the styrofoam recycling ring is

24 Plastic Waste Management Institute (2021), 2020 Production, Disposal and Recycling Status of Plastic Products. Tokyo: Plastic Waste Management Institute. https://www.pwmi.or.jp/pdf/panf2.pdf

steadily expanding.

- Because most styrofoams are made of a single material, the separation is easy. Heat, solvent, and compression can be used to reduce the volume. Styrofoam also has excellent recycling characteristics and is currently being recycled in three ways.

- Recycled as the base material for plastics and reused in plastic products

- Recycled as gas and oil with heat and pressure and reused as fuel

- Combustion creates a high amount of heat energy, and it is reused for power generation

As of 2020, Japan's rate of effective utilization of EPS (recycling rate) rose by 1.3% compared with the previous year, reaching 90.8% (thus, exceeding 90% again). Material recycling (MR) increased by 1.5% to 52.9% (0.8% of chemical recycling), energy recovery to 37.9%, and the ratio of unused waste (simple burning or landfill) to 9.2%. It is expected that the range of applicable products will be expanded to durable parts and products (rather than disposable ones).[25]

J-EPS provides recycled waste reduction machines to downtown wholesale markets, supermarkets, department stores, and waste disposal companies in Japan. The collection volume of styrofoam is 3,000 tonnes monthly, maintaining a high share (80%) in the industry.

- High melter
  - Has a broad range of processing capabilities (20–300 kg/H).
  - The volume reduction block features automatic molding and discharge.
  - Can be installed in processing businesses and manufacturing factories without taking up space.
  - Efficient deodorization eliminates odor and smoke generation.
  - Can reduce the volume of foams other than styrofoam, such as EPP, EPE, PSP, and XPS.
  - -Can be considered safe because the melting temperature is as low as 170°C.
  - -Installed in central regional wholesale markets, waste disposal companies, supermarkets, etc.[26]

25 Plastic Waste Management Institute (2022), *Plastic Products, Plastic Waste and Resource Recovery* [2020], PWMI Newsletter No. 51, Tokyo: Plastic Waste Management Institute

26 J-EPS recycling. (n.d.). *HIGH MELTER*. Retrieved from https://www.j-eps.com/high-melter

Figure 2-8 | Japanese J-EPS High Melter

[Table 2-7] Japanese J-EPS High Melter Performance

Type	RE-E201	RE-E502	RE-E1000B	RE-E1500A	RE-E2000A
Capability (kg/h)	20	50	100	150	200
Electricity (kW)	6.67	13.13	30.11	39.46	64.02
Weight (kg)	650	1125	3200	-	-

- Eco Robo Ace
  - Can handle large batches ranging from 100 kg to 400 kg/H max, and automatic supply and discharge are possible.
  - Storage tanks are equipped to standard for efficient workability.
  - As the grinding and volume reduction processes are independent, the installation can be laid out freely.
  - Safe because processing is based on frictional heat without actual heating.
  - The processing temperature is low and produces odor; it does not produce smoke or other phenomena.
  - There is little deterioration of the resin due to heat, and high-quality recycled materials can be obtained.

- Installed in national central wholesale markets, waste disposal companies, local governments, etc.[27]

<Figure 2-9> Japanese J-EPS Eco Robo ACE

- Clean Heat Packer
  - Broad processing capacity range (10–180 kg)
  - It can be installed in the garbage disposal sites of supermarkets and department stores without taking up space because of its compact design (it creates no noise because there is no grinding)
  - It is safe because the melting temperature is as low as 150°C–160°C.
  - Hot air heated by electric wire heaters circulates through the body of the melting machine, and odors are treated with activated carbon (catalyst).
  - No management personnel are required except to replace the receiving box, and it can be used as a garbage bin
  - It is installed in department stores, supermarkets, etc.[28]

27 J-EPS recycling. (n.d.). *ECOROBO ACE*. Retrieved from https://www.j-eps.com/eco-robo-ace

28 J-EPS recycling. (n.d.). *CLEAN HEAT PACKER*. Retrieved from https://www.j-eps.com/clean-heat-packer

<Figure 2-10> Japanese J-EPS Clean Heat Packer

② **PP**

Japan has a high recycling rate for PET bottles (78%), but PE, PP, and PS rates are known to be low (11%–20%). Polypropylene (PP), polyethylene (PE), and polyester (PS) are selected from veil products. Re-commercialized products, such as pellets, lint, and reduced volume products, are obtained. Re-commercialized products are used as plastic base material, manufactured into pallets, etc. Discarded electronic appliances collected from consumers at home appliance recycling plants through outlets under the Home Appliance Recycling Law (refrigerators, washing machines, air conditioners, and TVs) are inspected for refrigerants and mercury relays. Then, they are usually disassembled by hand or crushed by machinery. Discarded home appliances that have been disassembled produce mixed plastic, including iron, nonferrous metals, etc. Mixed plastic undergoes float/sink selection, wind selection, foreign substance removal, and later separated into different types (PP, PS, ABS, etc.). Plastic that has been separated is split by color through optical selection using infrared and is used to produce flakes. Flakes are then turned into pellets with standardized strength and hardness according to user quality requirements. Recycled waste plastic is a recycled base material for home appliances and two-wheeled vehicle parts.[29]

4. China

4.1 Plastic Industry

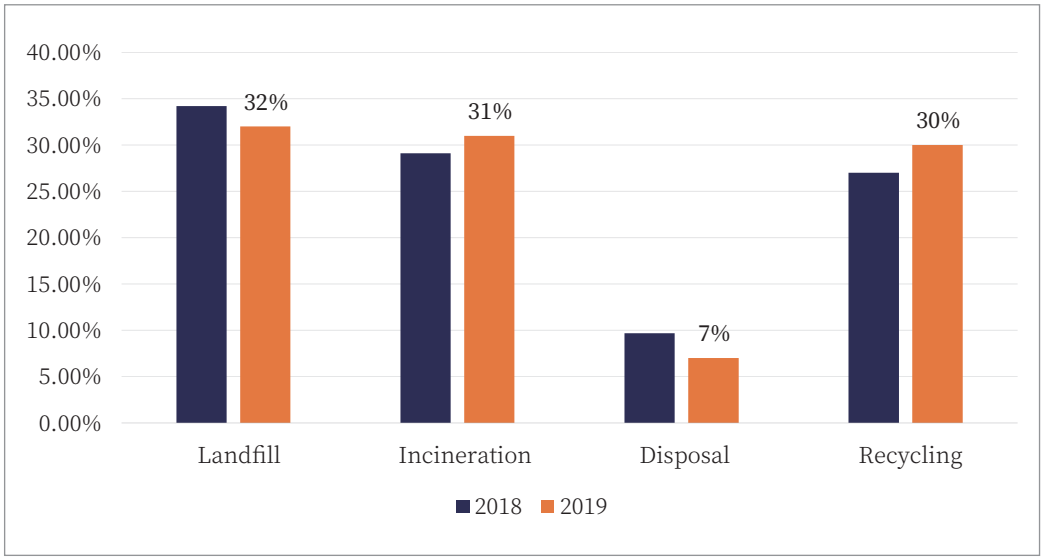
China is one of the world's biggest plastic users, accounting for approximately 20% of global plastic consumption. In 2019, China's single-use plastic consumption reached 40.2 billion pieces and was expected to reach 45 billion pieces by 2020. In 2020, 76,032.2 kt plastic products were produced in China, 135,877.0kt plastic products were domestically consumed,

29 Fukawa, I. (2019), *Current Status and Challenges of Plastic Recycling in Japan (PET vs PE, PP, PS, EPS)*. Tokyo: Asahi Research Center, https://arc.asahi-kasei.co.jp/report/arc_report/pdf/rs-1039.pdf

and only 16,000.0 kt were reused. Thus, the regeneration utilization ratio is only 17.6%.

Regarding the status of plastic production and recycling, China produced 63 million tonnes of plastic waste in 2019, of which 20.16 million tonnes were landfilled (32%), 19.53 million tonnes were incinerated (31%), and 4.41 million tonnes were discarded (7%). As of 2019, the overall recycling rate of plastic waste is 30%.[30]

<Figure 2-11> China's status of plastic production and recycling (2018–2019)



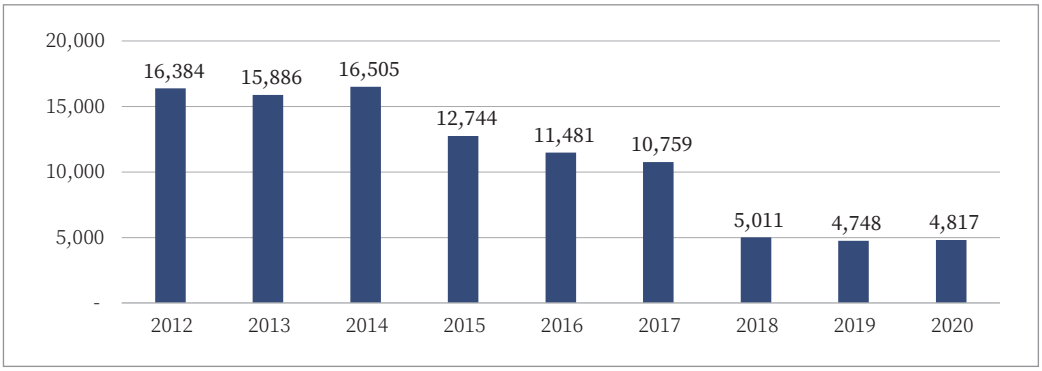
Source: Li, J. (2021)[31]

Before China announced its regulations on plastic import, half of the globe's plastics had been processed in China. The recyclable materials from overseas had not been cleaned and were mixed with non-recyclable materials, causing environmental pollution in China for a long time. In 2018, China announced that it no longer imports 24 types of solid waste, including unsorted paper and the low-grade polyethylene terephthalate used in plastic bottles. It set a new limit on the impurities in other recyclables. Since China announced the regulations to ban the import of some kinds of plastics, it has affected the global plastic supply chain. Mainly, the import trade value in 2018 decreased by almost 50% due to the waste import regulation enacted in 2018.

30 Zhanfeng, M. and Wanjun, J. (2021), *China plastic industry 2020*. China Plast 35, pp. 119–125. DOI: 10.19491/j.issn.1001-9278.2021.05.019

31 Li, J. (2021), *China's Plastic Recycling Policies and Challenges*. Presented at 2021 Jeju Plus International Environmental Forum for Zero Plastic Society. Retrieved from http://jplusforum.kr/files/session2/02_Plastic_Recycling_Policies_and_Challenges_in_China.pdf

<Figure 2-12> China's total import trade value of plastics (million USD) (2012–2020)



Source: UN Comtrade (accessed in February 2022)[32]

4.2 Law and Policy

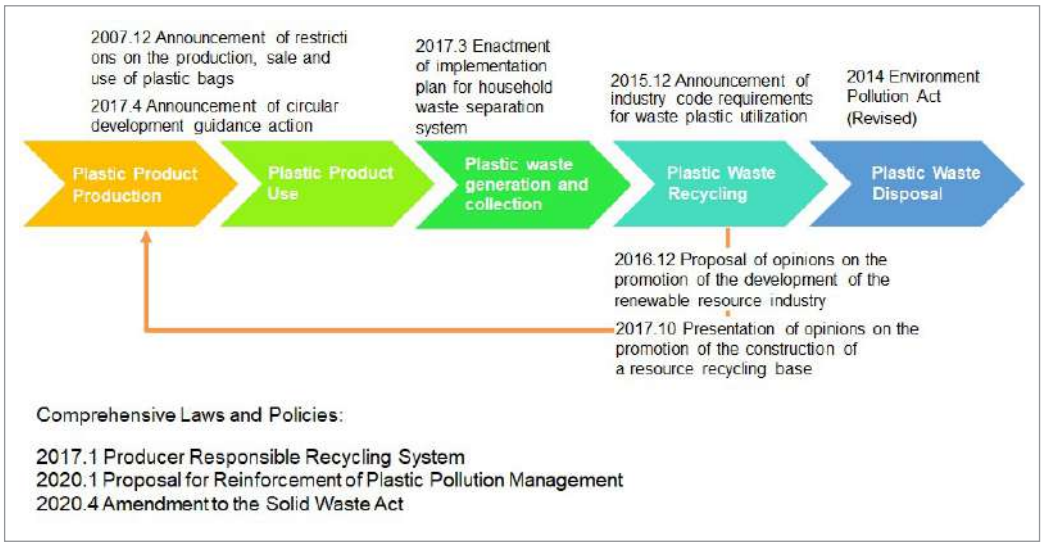
China has been the world's largest importer of waste for many years, but there have been concerns that it could lead to pollution if not recycled and properly disposed of. Since the 1980s, China has imported solid waste, washed and crushed by Chinese domestic companies, and processed it into industrial raw materials. Since then, China has phased out imports of plastics, automobile parts, paper, textiles, scrap metal, and wood. Particularly, the import ban on waste plastics at the end of December 2017 significantly impacted China's recycled polyester industry. In 2017, China announced bans on plastic waste based on the Technical Barriers to Trade in WTO. According to the articles in the agreement, China has begun to ban the import of plastic waste.[33]

In 2020, China's government released a series of laws and regulations, the amendment to the Solid Waste Act was passed in April 2020, and on January 19, 2020, the National Development and Reform Commission and the Ministry of Ecology and Environment jointly announced the "Proposal for Reinforcement of Plastic Pollution Management" and announced step-by-step goals for plastic pollution management.

32 UN Comtrade. https://comtrade.un.org/data/ (accessed in February 2022)

33 Yoshida, A. (2005), China: the world's largest recyclable waste importer. In: Kojima M (ed) *International trade of recyclable resources in Asia*. Institute of Developing Economies, pp 33–52.

Figure 2-13 | Key laws and policies enacted in China



- Solid Waste Act

The Standing Committee of the National People's Congress ("NPC") approved an amendment to the Solid Waste Act. The amendment introduces substantial changes, some of which significantly impact companies in China. For example, the revision provides a new exclusion from the definition of "waste," creates a series of new obligations on waste generators, sets out a solid legal basis for bans on waste imports and single-use plastics, increases monetary penalties for noncompliance, and adds other types of penalties for violations. The revised solid waste law will take effect on September 1, 2020.

In case of obligations, waste generators should establish an industrial solid waste management ledger to record the types, quantities, flow, storage, utilization, disposal, and other information about their industrial solid wastes, to facilitate the traceability of such wastes. Otherwise, they will be penalized. The revision has impacts on the extended responsibility of waste generators. The waste generator would be liable for any environmental damages it.

China currently allows importing limited types of solid wastes as raw materials. The amendment requires gradual movement toward achieving "zero" imports of solid wastes (Article 24). Illegal importers will face a fine of RMB 50,000 to 5 million, and carriers will be held jointly liable for the smuggling of solid wastes (Article 115). The revised Solid Waste Law reinforces the waste generators' monitoring system and responsibility.

- Proposal for Reinforcement of Plastic Pollution Management

From January 1, 2021, the production and sale of foamed plastic food containers and plastic cotton swabs were banned in China. Also, daily chemical products containing microplastics are banned from production from 2021 and sales from 2023. Except for Beijing, Shanghai, Zhejiang, and Hainan in China, the governments of each province and autonomous region also announced plastic restrictions and ban policies, and the phased goals are clarified as shown in the table below. Although there are regional differences, most of them aim to ban some regions and products from 2021, significantly reduce plastic usage by 2023, and significantly reduce the rate of landfilling of waste plastics by 2026. Hainan is a leading province where plastic restrictions and bans were enacted in January 2020.[34]

[Table 2-8] The step-by-step objective of Reinforcement of Plastic Pollution Management

Category	2021	2023	2026
1. Plastic products with sales ban and production			
Foamed plastic food container, plastic cotton swab	Nationwide prohibition of sales and production	-	-
Chemicals containing microplastic fragments	Nationwide prohibition of production	Nationwide prohibition of sales	-
2. Plastic products with regulated usage			
Non-degradable plastic bag	Prohibited for use in stores, marts, pharmacies, bookstores, food delivery, various exhibitions, and agricultural markets in the directly administered city, independent planned city	Prohibited for use in shops, marts, pharmacies, bookstores, food delivery, and various exhibitions in areas constructed within prefecture-level or higher in cities and coastal counties	Prohibited for use in agricultural markets in areas built in cities above the prefecture-level, within the prefecture-level, and areas built in coastal counties
Single-use plastic container	Prohibition of single-use plastic containers in tourist restaurants in Prefecture-level cities or higher prefecture-level cities	Prohibition of single-use plastic containers in tourist restaurants in counties	30% reduction in consumption of disposable tableware that cannot be degradable in prefecture-level cities and food delivery areas in prefecture-level or higher cities
Single-use plastic products in hotels	-	Nationwide prohibition of providing single-use plastic products in hotels	All hotels, inns, and guesthouses are prohibited from voluntarily providing single-use plastic items.

34 Kim, H.Y. and Ye, H.T. (2021), *China's Plastic Restriction Policy Implementation Status and Implications*. KITA Market Report. Korea International Trade Association. Retrieved from https://www.kita.net/cmmrcInfo/rsrchReprt/ovseaMrktReprt/FileDown.do?nIndex=1&nPostidx=40089&type=2

Category	2021	2023	2026
Plastic packaging		Prohibition of the use of non-degradable plastic packaging at post office delivery points in provinces (cities), such as Beijing, Shanghai, Jiangsu, Zhejiang, Fuze, and Guangdong	Nationwide prohibition of non-degradable plastic bags and tapes at post offices

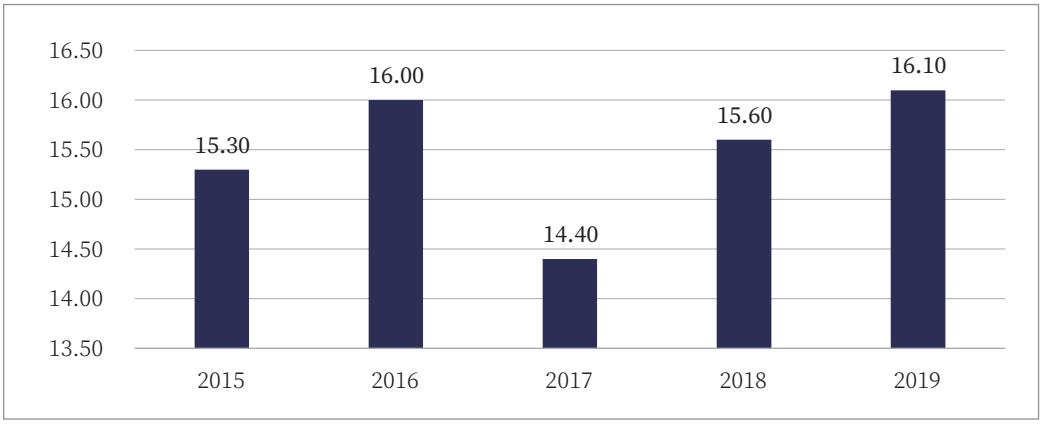
Source: Kim and Ye (2021)[35]

4.3 Recycling Technology

According to the China Resource Recycling Association, China produced 16 million tonnes of recycled plastics in 2019, showing an increasing tendency after 2017. Since the import ban on waste plastic, China may stimulate more investments in the plastic recycling and manufacturing industries.

<Figure 2-14> Amount of recycled plastics made by processing waste plastics

(million tonnes)



Source: China Resource Recycling Association

PP is widely used in packaging, home appliances, automobiles, medical protection products, and infant products in the form of hemp bags, injection molding, thin films, fibers, and steel pipe materials. In China's PP consumption structure, packaging, automobile, and home appliance industries are the largest consuming markets for PP, and knitted fabrics, injection-molded products, and BOPP thin films are major PP applications (knitted fabrics, injection-molded articles, and BOPP are 32%, 28%, and 18%, respectively).

China already has 70 PP producers. Currently, state-owned companies, such as Sinopec, China Petroleum (CNPC), and China Offshore Oil (CNOOC), joint ventures, such as SK-

35 Ibid.

SINOPEC and Aramco-SINOPEC-SABIC, and Hengli Petrochemical Private companies, such as 恒力石化) and Zhejiang Petrochemical Corporation (浙江石化) are forming a competitive landscape. Among them, Sinopec's PP production capacity is the highest at 26%, followed by China Petroleum (CNPC) with 18%.

In the coming years, China's PP production capacity will develop rapidly. It is predicted that in 2023, the output will exceed 35 million tonnes, and the self-sufficiency rate will reach 90%. However, among the PP products produced in China, the production of unique materials with high performance and high added value is small. It is expected to be imported mainly through Korea, Japan, and Southeast Asian countries, as there remains a shortage in the high-end PP sector.

According to an interview with a chemical industry sales company, China has significantly changed consumption habits and patterns. Currently, China is exploring and developing chemical recycling technologies for producing high-quality recycled plastic from home delivery packaging and single-use food containers, among other things. High-end PP products are increasing in specific fields, such as high-gloss appliances and heated canned food packaging containers. Compared with products of the same type, Korean PP products have high technology, quality, and cost-effectiveness and thus have a significant market share in downstream factories. In other words, some factories still want to use them even though they are expensive. However, existing countries, such as Saudi Arabia, Thailand, Singapore, and the United Arab Emirates, are also improving their technology and increasing price competitiveness, so competition is expected to intensify in the future.[36, 37]

[Table 2-9] Recycling methods implemented in China

Category	Method
Material recycling	**Closed-loop material recycling**: This method generates raw materials for the same product they came from.
	Open-loop material recycling: This method generates raw materials for less quality products than the original product.
Chemical recycling	**Raw materialization/monomerization**: This method chemically decomposes waste plastic to restore it to raw materials or monomers.
	Gasification: A method that uses gasification melting or other chemical processes to extract flammable gas.
	Petrochemical extraction: A method that uses thermal decomposition or a catalytic reaction to heat the material and extracts fuel or chemical raw materials from it with a chemical reaction.
	Blast furnace raw materialization: Uses the material as iron ore reducing material in a blast furnace.

36 Ryu, B. (2020), *China Polypropylene (PP) Market Trend.* Korea Trade-Investment Promotion Agency, https://dream.kotra.or.kr/kotranews/cms/news/actionKotraBoardDetail.do?SITE_NO=3&MENU_ID=430&CONTENTS_NO=1&bbsSn=254&pNttSn=183774

37 Cui, C. (2019), 5 *lessons from China's push to increase domestic recycling*, Greenbiz. Retrieved from https://www.greenbiz.com/article/5-lessons-chinas-push-increase-domestic-recycling

Category	Method
Chemical recycling	**Coke oven chemical raw materialization**: Mixes the material with a component, such as coal, for use as a raw material.
Thermal recycling	**Waste incinerator power generation**: This method burns waste in a boiler and generates power from the high temperature/high-pressure steam obtained.

4.4 Recycling Process

- EPS Mechanical recycling

After smashing, the EPS foam waste is hot melted for recovery and recycling after incorporating a foaming agent, flame retardant, nucleating agents, and processing XPS (extruded polystyrene) foam[38]. Now, China's recycling technology is advancing, and it has become one of the most critical paths for EPS recycling.

As regards recycling, when paired with the new advanced technology, foam manufacturers' scrap and non-qualified goods can be crushed into particles of a specific size. Pearl particles, created from EPS foam products of various specifications and shapes, form again on sheet metal or package forming machines. Under the premise of shattered particles between the dose of 10% and 25%, product performance that satisfies the national standard (GBl0801-2002) can save raw materials 10%–25%.

Regarding hot melt regeneration, when EPS scrap foam is baked at constant temperatures of 140°C–190°C, it shrinks off bubbles, cools down, crushes, and produces combustible gas, necessitating adequate exhaust measures and attention to production safety. Another method is scrap breaking, followed by melt extrusion, heating, chilling, and cutting into recycled pellets using screw foam particle forces connected in the extruder barrel. There is also a technique in which EPS scrap foam is soaked in a high-boiling solvent, causing it to foam and gel. It is then mixed with modified resin, additives, multi-stage exhaust extrusion granulation, and condensation for solvent recovery. After being dried to a solvent content of 6%–l0%, gels generated from the grains can be used again to produce polystyrene foam products again.

- Production of lightweight thermal insulating building materials.

Waste-foamed plastics are crushed using infrared radiation heating to less than one-twentieth of their original size. Then, they are mixed with special cement created from rice

38 Juliazhu China EPS foam recycling situation and technology progress | ... https://www.environmental-expert.com/articles/china-eps-foam-recycling-situation-and-technology-progress-358166 (accessed March 30, 2022).

flower sugar-like building material deemed non-combustible. Silencers like these constitute approximately 60% of building materials and can reduce noise by up to 90% at specific frequencies.

This material is presently being utilized to soundproof the facility's walls and ceiling. EPS foam crushing ingredients can also be used to make light blocks, external wall insulation mortar, and light mortars. It is also possible to glue a mixture of clay and EPS foam crushing material in a particular proportion, bake in the heat, and burn the EPS foam crushing material, resulting in a hollow clay brick with high strength and outstanding thermal insulation properties[39].

- Chemical recycling

D-limonene is a natural vegetable oil extracted that, aside from being safe, highly soluble, stable, and good smelling, dissolves only EPS, meaning that other components, such as expanded polyolefins and labels, can be easily removed from the limonene solution by filtering it. In this process, the oil phase is formed by directly dissolving the EPS in d-limonene. By dissolving EPS in d-limonene at room temperature (30°C), different concentrations of EPS (3, 5, 10, and 15 wt%) can be generated. Water with PVA as a stabilizer constitutes the non-solvent phase. The solution is prepared by slowly adding PVA powder to water at 70°C and stirring for 6 h at 300 rpm. Stir the solution until the PVA is completely dissolved and no air bubbles are visible.

PS particles are created by utilizing the oil-in-water (o/w) emulsification-diffusion process from EPS solutions in d-limonene. 1-mL PS solution (oil phase) is dropped into a 10-mL PVA solution, one by one (non-solvent phase, continuous phase). This solution is homogenized for around 20 min at 600 rpm to emulsify it. To aid the diffusion of the organic solvent into the ongoing water phase, 400 ml of water was added to this emulsion and moderately agitated at 300 rpm and 60°C for 24 h. While stirring continues, a condensation process eliminates some limonene and water from the system. The resulting dispersion is centrifuged, and the liquid in the supernatant is extracted with a micropipette. The particles settling at the bottom were washed repeatedly with distilled water to remove the PVA coating from the PS particle surface and dried in a hot air oven at 60°C for eight hours to acquire the dry PS particles.

Despite its high boiling point (176°C), limonene forms a minimum boiling azeotrope with water, lowering the operating temperature to 97.4°C. Condensation utilizing a

39 Harden Machinery Ltd. (2013), China EPS foam recycling situation and technology progress, Environmental XPRT. Retrieved from https://www.environmental-expert.com/articles/china-eps-foam-recycling-situation-and-technology-progress-358166. Accessed March 30, 2022

hydrodistillation method is used to obtain 24 d-limonene from the procedure. After stirring (300 rpm) and heating (60°C), the emulsion and adding surplus water, it is connected to a condenser, where the limonene and water vapors are condensed, and the liquid mixture is collected. Due to the partial miscibility of d-limonene and water, the solvent-rich phase will float to the top and can be separated using a separating funnel[40].

- PP recycling

The most used is mechanical recycling; the polymer is unaltered during this process. This is a physical method in which plastic wastes are cut, shredded, or washed into granulates, flakes, or pellets of suitable quality for production and then melted to generate a new product by extrusion. Reprocessed material can also be used with fresh material to achieve better results. Waste plastic will drastically decrease after it is sorted, cleaned, dried, and turned into end products. Then, the feedstock or chemical recycling can complement the mechanical method; chemical recycling is the chemical conversion of polymers to monomers or partially depolymerizing polymers to oligomers via a chemical reaction. The resulting monomers can be utilized to recreate the original or a comparable polymeric product via new polymerizations. This technique can turn the plastic material into smaller molecules appropriate for feedstock materials, starting with monomers, oligomers, or combinations of various hydrocarbon compounds[41].

40 Mangalara, S. C. H., & Varughese, S. (2016). Green recycling approach to obtain nano- and microparticles from expanded polystyrene waste. *ACS Sustainable Chemistry and Engineering, 4* (11), pp. 6095–6100. https://doi.org/10.1021/ACSSUSCHEMENG.6B01493

41 Grigore, M. E. (2017). Methods of recycling, properties and applications of recycled thermoplastic polymers. *In Recycling*, 2 (4), MDPI AG. https://doi.org/10.3390/recycling2040024

03

CHAPTER

Status of Plastic Waste Management in Ecuador

1. Plastic Waste Management in Ecuador
2. Analysis of the Plastic Industry in Ecuador
3. Recycling Technology

Status of Plastic Waste Management in Ecuador

1. Plastic Waste Management in Ecuador

The Ecuadorian government, which has a primary-oriented industrial structure highly dependent on agriculture, fisheries, and crude oil, is attempting to transform the industrial structure into a manufacturing industry. The National Institute of Statistics and Census (INEC) indicates that the country generates approximately 14.4 thousand tonnes of waste daily, up to 0.86 kg daily per citizen.

1.1 Municipal Waste Management

A general description of municipal waste management can be divided into four sections: Project implementation, Inorganic residue utilization, Inclusive recycling, and Organic waste Treatment.

① Project Implementation: The GADS has the authority to give appropriate permits to any project related to construction or any business (food services, company, etc.) to adjust to meet requirements for committing to environment-friendly regulations. 54% of all projects are technically viable to meet the appropriate waste management and solids final disposal.

② Inorganic residue utilization: Some solid recycled residues are used again for other purposes in some GADS. 37% is referred to as the percentage of Gads, not to solid waste percentage. It is hard to determine each component, but it is more referred to using some part of solid residue. However, there are no data for each component.

③ Inclusive Recycling: Most of the recollection is performed by informal recyclers. 24% of GADS works directly with base recyclers (informal recyclers).

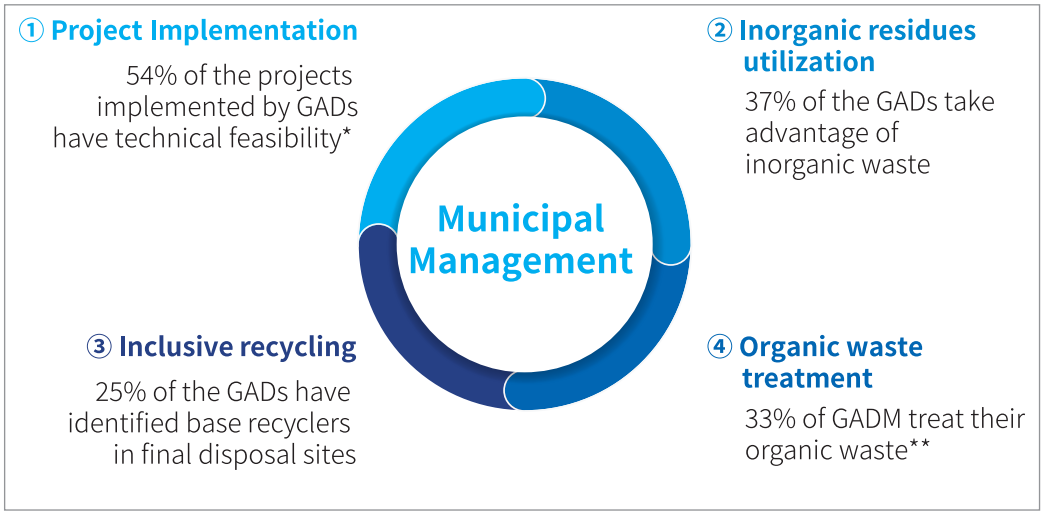
④ Organic Waste Treatment: Only 33% of GADs do any treatment for organic wastes. The rest of GADS cannot make any treatment due to geographical limitations. . They use some organic waste as a natural fertilizer for different crops

[Table 3-1] Source separation percentage per province[42]

Region	Province	% Source separation
Amazon	Zamora Chinchipe	77.8%
	Morona Santiago	75.0%
	Sucumbíos	57.1%
	Napo	40.0%
	Pastaza	25.0%
	Orellana	25.0%
Coast	El Oro	28.6%
	Guayas (Guayaquil)	4.0%
	Esmeraldas	0.0%
	Los Ríos	0.0%
	Manabí	0.0%
	Santa Elena	0.0%
Galápagos	Galápagos	100.0%
Highlands	Pichincha (Quito)	87.5%
	Carchi	83.3%
	Imbabura	83.3%
	Cañar	71.4%
	Loja	50.0%
	Azuay (Cuenca)	46.7%
	Tungurahua	33.3%
	Cotopaxi	28.6%
	Chimborazo	10.0%
	Bolívar	0.0%
	Santo Domingo	0.0%
Nationwide		33.6%

42 Estadística de Información Ambiental Económica en Gobiernos Autónomos Descentralizados Municipales - Gestión de Residuos Sólidos 2020. (2021, December). Instituto Nacional de Estadística y Censo. | https://www.ecuadorencifras.gob.ec/documentos/web-inec/Encuestas_Ambientales/Municipios_2020/Residuos_solidos_2020/Presentacion_residuos_2020.pdf (accessed July 16, 2022)

<Figure 3-1> General information on Municipal Waste Management



*Environmental permits, registrations, and licenses granted for executing the project
**65% of the waste in the country is of organic origin

1.2 Municipal GADs' Urban Waste Management

Ecuador has 221 GADs, of which only Quito and Guayaquil generate 40% of the waste nationwide. Of those GADs, several are composed of small and micro municipalities that have joined to form the Commonwealth. Consequently, different agreements may appear to share solid waste management, tourism, conservation, food sovereignty, and control of natural resources, among others. Examples of a commonwealth centered solely on waste management include small cities, such as Colta, Alausí, and Guamote (Highlands)[43].

43 *Mancomunidades y consorcios inscritos.* (2021, December 15). Consejo Nacional de Competencias. | http://www.competencias.gob.ec/mancomunidades-y-consorcios-inscritos/ (accessed July 18, 2022)

<Figure 3-2> Municipal waste management model

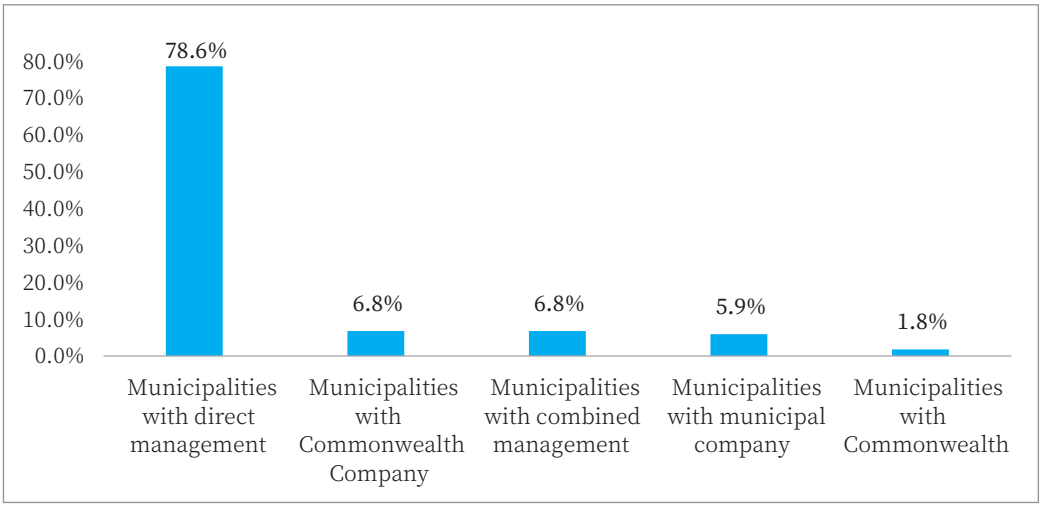


Figure 3-2 shows that in 2020, 78.6% of municipalities directly managed solid waste, as opposed to 15.4% of GADs that managed it through some type of association. Most of the larger cities like Quito, Guayaquil, and Cuenca manage urban solid wastes through municipal companies. For example, Cuenca manages their urban solid wastes through EMAC EP, from collection to landfill disposition/management. Conversely, Guayaquil has a municipal company in charge of the collection, while Consortium ILM, another municipal company, manages the disposition and management of landfill "Las Iguanas."

(1) Waste collection and disposal in the metropolitan cities of Ecuador

In Ecuador, the waste collection is 85.5%, implying that 14.5% of the waste is not collected. Of the 12,400 tonnes collected daily, 15% is collected via special routes for non-recycled and recycled waste. The country has a national color standard for waste separation to stimulate source separation and differentiated collection, which has not been implemented yet. Besides, the city of Cuenca (the third largest city, with a population of approximately 300,000) implemented a fine system for citizens who do not separate their waste. In the country, 70% of the waste trucks exceed their useful life of ten years. In Quito, the waste collection is conducted by the municipality company EMASEO (Empresa Pública Metropolitana de Aseo).

Besides, EMGIRS (Empresa Pública Metropolitana de Gestión Integral de Residuos Sólidos) operates the two transfer stations, the three construction and demolition waste landfills, and the "El Inga" landfill in Quito (DMQ). The North Transfer Station (NTS) has the highest waste storage capacity at 1,150 tonnes daily. NTS is formed by 11 platforms and

a transport fleet of 11 trucks with a capacity of 26 to 30 tonnes each. The South Transfer Station has a capacity of 900 tonnes/day. Seven hundred and twenty trips are made monthly from the South Transfer Station to the landfill.

In 2016, the Metropolitan Area of Quito and EMGIRS developed the Master Plan Integral Waste Management of the Metropolitan District of Quito. This plan is a technical framework for municipal solid waste (MSW) management until 2025. The main goal of EMGIRS is to maintain and operate the North and South Transfer Station reducing the amount of MSW going to "El Inga" landfill. While in most of the small and medium municipalities where the public health departments organize the collection and final disposal using their equipment, bigger cities subcontract (inter) national private companies like Gadere Veolia (among others in Quito, Cuenca, and Guayaquil) and EMAC (Cuenca).

[Table 3-2] Waste Treatment Activities of Municipal Companies in Ecuador

City (Province)	City (Province)	Activities
Quito (Pichincha)	EMASEO (Municipal Company)	• ***Non-Mechanized Collection***: This concentrates the services related to the solid waste collection through a manual system. • ***Differentiated Collection***: Citizens from specific neighborhoods are requested to separate recyclable waste into different bags for disposal. Informal recyclers are responsible for collecting, classifying, and marketing waste. • ***Mechanized Collection*** • ***Special Collection***: (i) On Sundays, old furniture, damaged appliances, used tires and construction debris. (ii) storage devices/waste pickers for collecting plastic, cans, tetrapak, and glass. (iii) Containers to collect special and hazardous household waste • ***Sweeping***[44]
	EMGIRS-EP (Municipal Company)	• ***Landfill***: Waste Treatment and Disposal[45]
Guayaquil (Guayas)	Urvaseo (Municipal Company)	• Collection, sweeping, and transportation of non-hazardous solid waste in the city and some of its rural parishes.[46]
	Consortium ILM –Las Iguanas	• ***Landfill***: Waste Treatment and Disposal • Private company, the municipal of Guayaquil, established a public contract with any other company that can manage the final disposal of solid waste. (The Consortium ILM won this contract)

44 *Conoce sobre todos nuestros servicios - Emaseo Ep*. (2022, April 5). Emaseo EP. | http://www.emaseo.gob.ec/servicios/ (accessed July 18, 2022)

45 *RELLENO SANITARIO DEL DISTRITO METROPOLITANO DE QUITO*. Empresa Pública Metropolitana de Gestión Integral de Residuos Sólidos. | https://www.emgirs.gob.ec/index.php/zentools/zentools-slideshow

46 *Servicio de recolección* – URVASEO. (n.d.). URVASEO. | https://urvaseo.com/servicio-de-recoleccion/ (accessed July 18, 2022)

City (Province)	City (Province)	Activities
Cuenca (Azuay)	EMAC EP[47] (Municipal Company)	• ***Collection***: collects solid waste and recyclable materials from households differentially. • ***Green Areas***: maintenance and arrangement of green spaces in the city. • ***Sweeping***: cleaning and sweeping of the streets, avenues, markets, rural parishes, and public spaces • ***Special Residues***: collection, disposal, and management of (i) debris, (ii) recyclables - inclusive recycling through base recyclers, and (iii) hazardous waste. • ***Landfill***: management • ***Biogas Plant***: Use of Biogas extracted from the landfill[48]

In Autonomous Decentralized Municipal Governments (GADM), 45.7% of the municipalities have landfills, 28.8% dispose of their waste in temporary cells, and 25.6% in open dumpsites or ecosystems. In Ecuador, there are 144 open dumpsites and 77 landfills. The National Program for the Integral Solid Waste Management planned to close the dumpsites before the end of 2017 but has not started this process yet.

In 2017, 53% of the municipalities conducted differentiated hospital waste collection. 50% of these municipalities do not have facilities for the treatment or final disposal of this hazardous waste stream. In 2017, 212 of the 220 municipalities swept 18,248.4 kilometers of streets, covering 78% of the roads.

(2) Waste collection and disposal in small-medium sized cities in Ecuador

Smaller GADs like Otavalo managed their wastes directly or with a municipal company. Although smaller cities include basic waste management (collection, sweeping, and disposal), it is common to see citizens involved in training and waste collection activities.

Playas is a city belonging to the Guayas States. The municipal company named EMAPLAYAS EP collects and transports the non-hazardous solid waste. Additionally, they conduct a campaign named Neighbor's "Minga," which encourages people to collect the waste on the street and make residents aware of environmental habits relating to the proper management of solid waste. Also, the municipal administration manages the landfill and waste disposal.

47 EMAC-EP : Empresa Municipal de Aseo de Cuenca

48 *Servicios - EMAC*. (n.d.). EMAC EP. | https://emac.gob.ec/servicios/recoleccion/ (accessed July 18, 2022)

[Table 3-3] Companies in charge of waste management in small cities

City (Province)	Company	Activities
Playas (Guayas)	EMAPLAYAS EP (Municipal Company)	• Collection and transportation of non-hazardous solid waste • Sweeping and cleaning • Neighbor's "Minga": Collection of wastes on the streets to make residents aware of environmentally friendly habits relating to the proper management of solid waste
	Municipal administration	• Landfill: Waste disposal[49]
Otavalo (Imbabura)	Municipal administration	• Waste Collection: Collection schedules differ between organic and inorganic wastes • Citizen training on waste separation/classification • Landfill: Waste treatment and disposal[50]

1.3 Value Chain

(1) Recycling- EPR

According to the National Institute of Statistics and Censuses (INEC), only 6% of the municipality's waste is recycled nationwide. In 2017, approximately 626,000 tonnes of cardboard, metal, paper, plastic, and glass wastes were recycled.

In 2015, the national network of waste pickers in Ecuador (RENAREC) stated that approximately 20,000 informal and formal waste pickers are responsible for collecting recyclable waste.

Extended Producer Responsibility (EPR) Programs are implemented for a series of waste streamed through the Ministerial Agreement 161 "Regulation for pollution prevention and control of chemical substances, hazardous and special wastes," including used tires (2014), containers of agricultural pesticides (2013), and batteries and cell phones (2013). The Agreement obliges producers to meet the established collection or recycling targets. Otherwise, a ban on the sale or import of the product is imposed.

The Ministerial Agreement 098 of 2015 regulates the extended producer responsibility program for used tires. By 2019, approximately 2.6 million vehicles generated 3.14 million End of Life Tires, equivalent to 51,266 tonnes, of which 23,070 tonnes (45%) were collected

49 Sotomayor, D. (2022, July 17). Viviendo entre ratas y basura en el botadero municipal de Playas. Expreso. | https://www.expreso.ec/guayaquil/viviendo-ratas-basura-botadero-municipal-playas-131747.html (accessed July 18, 2022)

50 Se retoma la clasificación domiciliaria y se reubicará contenedores en Otavalo. (2020, January 23). Gobierno Autónomo Descentralizado Municipal Del Cantón Otavalo. | http://www.otavalo.gob.ec/noticias/itemlist/tag/Direcci%C3%B3n%20de%20Gesti%C3%B3n%20Ambiental.html (accessed July 18, 2022)

by different companies to transform them into other products, such as playgrounds, carpets, and synthetic courts or energy. The biggest EPR program is Seginus, representing 80% of the used tire-producer companies.

In 2018, Ecuadorians produced 93,000 tonnes of electrical and electronic waste, approximately 5.4 kilos per person. Only 2% of this amount was recycled. The Ministry of the Environment and Water is structuring the technical proposal for the EPR legislation to increase formal recycling as soon as possible. Currently, five registered EPR E-waste programs, including Reinicia, Reciclametal, and Vertmonde, offer their services to the producers to comply with this legislation. Ecuador has not yet had an EPR program for packaging, although developments are expected in this regard in the future.

Currently, the EPR is only applied to hazardous or special wastes, such as plastic waste for agricultural use, used tires, batteries, and electronic devices.

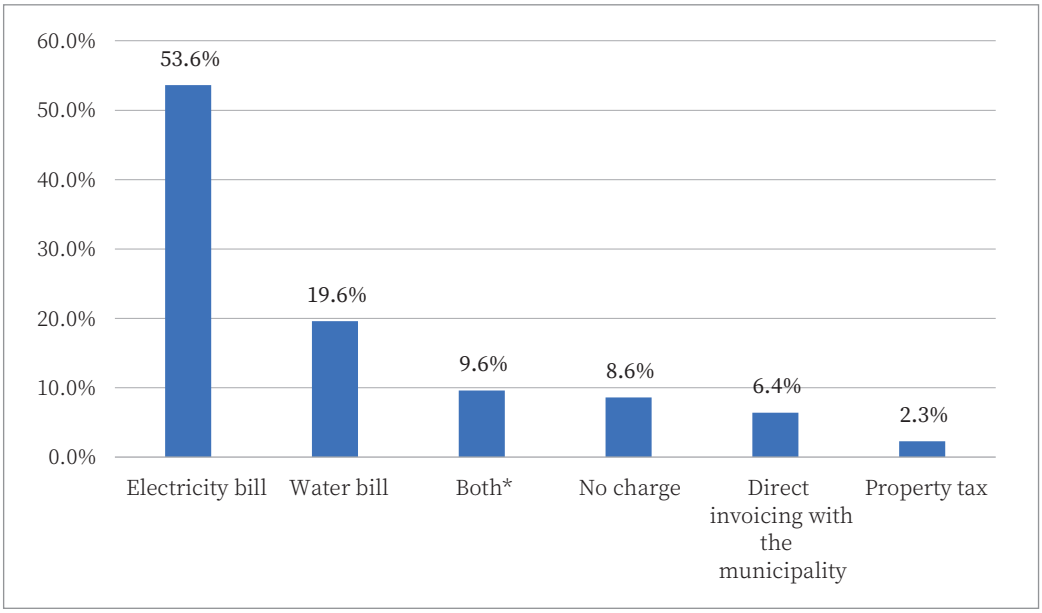
PET bottles are the only plastic and plastic products with a tax (Impuesto Redeemable de botellas plastics no retornables -PET- IRBP). This tax is focused on a non-returnable bottle containing any drink. This tax must be paid to the bottle manufacturers or the imported bottle companies. The fare is USD 0.02 per bottle. This tax was created by the Law for Environmental Promotion and Optimization of State Income (Ley de fomento ambiental y optimizacion de los ingresos del estado S.R.O. 583 de 24-11-2011).

The EPR system is currently designed for hazardous and special wastes. IRBP imposed on PET bottles will finish in 2023. Therefore, the Ministry of the Environment is currently working on an EPR on containers and packaging, including plastics, glass, tetra packs, cardboard, and cans. This new EPR will be applied by the end of 2023.

(2) Waste Management Tax

Financing of solid waste management is managed differently since it involves 221 GADs with different realities. Hence, the method of charging local services, such as waste management, will differ among local governments. Figure 3-3 shows the different methods available throughout the Ecuadorian GADs for citizens to pay for the waste management service.

<Figure 3-3> The method selected to collect waste management tax (nationwide)



Through municipal ordinances, GADs determine the amount and waste management tax payment method. Table 3-4 shows two examples of how different cities collect waste management taxes. For example, Guayaquil determined a fixed percentage on the electricity or water monthly bill. Conversely, Cuenca has a detailed ordinance where the tax varies depending on the type of waste generator. Other cities do not count on an ordinance to establish waste collection tax.

[Table 3-4] Waste Management tax in Guayaquil and Cuenca

City (Province)	Law/ Ordinance	Method	Standard
Guayaquil (Guayas)	Official Register No. 1626	Electricity/ Water Bill	Waste management tax: 12.5% of the tax base. Tax base: For households consuming 300 kWh monthly, the tax base will be the monthly electricity consumption. For those who consume less, the tax base will be the value of the monthly water consumption and use of the sewage service. Exemptions: transmitting antennas, advertising structures, and taxpayers who own aquaculture and agricultural properties.
Cuenca (Azuay)	Ordinance 328	Direct invoicing	Waste management tax: A formula is applied depending on the type of waste generator Waste generator classification: Common generators Big generators Infectious waste generators Special generators Waste generators during events or gatherings Owners or possessors of one or more real estate Generators of construction waste or rubble

1.4 General Municipal Management Information

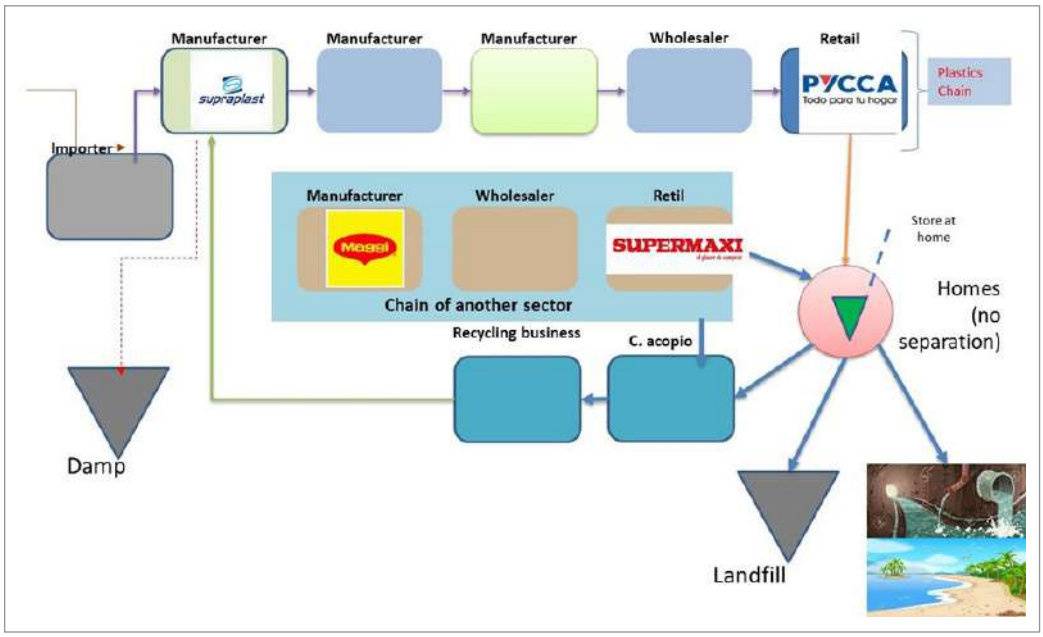
This chart reflects the logistical path of plastics in the city of Guayaquil. This chart can be a representative of a city in Ecuador. The process starts with local companies that import and then sell raw plastic materials to manufacturers. Some manufacturers also get their raw plastic materials from brokers outside the country. Notably, most plastics manufacturers are in Guayaquil, Quito, and Cuenca metro areas. Some plastic products will be part of some industries, such as the food industry. Other plastic products will be sold directly to retailers or small shops.

There are three types of retailers. One sells appliances, clothing, computers, furniture, home products, or kitchen equipment. Pycca is in this group. These retailers sell products packaged in single-use plastics. Some retail products are wrapped in packages or containers (plastics, paper, or cartonnes). These materials from the packaging are also collected without separation at the homes. Other retailers are supermarkets or wholesalers like Supermaxi, Tia o Mi comisariato-. They mainly sell food products. In the same line, there has been an increase in some big wholesalers or retailers like Walmart U.S.stores. There is another group composed of small shops around the cities in the country. They are mainly located in low-income areas to supply food needs to customers. Besides all the groups, there are food markets located in big and small cities or rural areas.

Generally, people buy products from supermarkets, wholesalers, shops, or food markets. Some of them are stored in cupboards or cabinets in homes. Other plastic products, such as tables or buckets and chair areas, are used in the home for a medium or long time. However, in most Ecuadorian cities, many plastics are used as single-use plastics, such as bags, bottles, or packages, that are usually recollected in garbage bags without any separation. These garbage bags are collected from the municipal company using garbage trucks and transported to landfills.

The city also has a formal business and a network of informal businesses to recollect waste and transport it to drop-off Centers (Centro de Acopio). These centers recollect solid waste, and these materials are bought by recycling business companies. These companies sell to manufacturers. Scarcely amount of solid waste leaks into rivers or space for the city's drainage system.

<Figure 3-4> Waste management flowchart in Ecuador



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1.5 Governance of Waste Management

(1) Laws and Regulations on Solid Waste

The Organic Code of Territorial Organization, Autonomy and Decentralization (Código Orgánico de Organización Territorial, Autonomía y Descentralización **COOTAD** (2010)) is the base law for Decentralized Autonomous Governments (GADs)' establishment. Moreover, COOTAD affects the Decentralized Autonomous Governments (GADs) responsibility for managing solid waste. The GAD is directly responsible for providing waste management services and maintaining waste management operations, i.e., sanitary landfills. The Ministry of the Environment provides the technical feasibility of the management by granting environmental permits and authorizations.

Regulation of the Organic Code of the Environment (Reglamento al Código Orgánico del Ambiente **RCODA** (2019)) specifies the responsibilities of different parties, such as GADs, ministries, companies, and institutions on the environment. Also, RCODA specifies when authorization is required through registration or environmental licenses. This regulation manages inclusive recycling, such as the responsibilities of base recyclers/waste pickers.

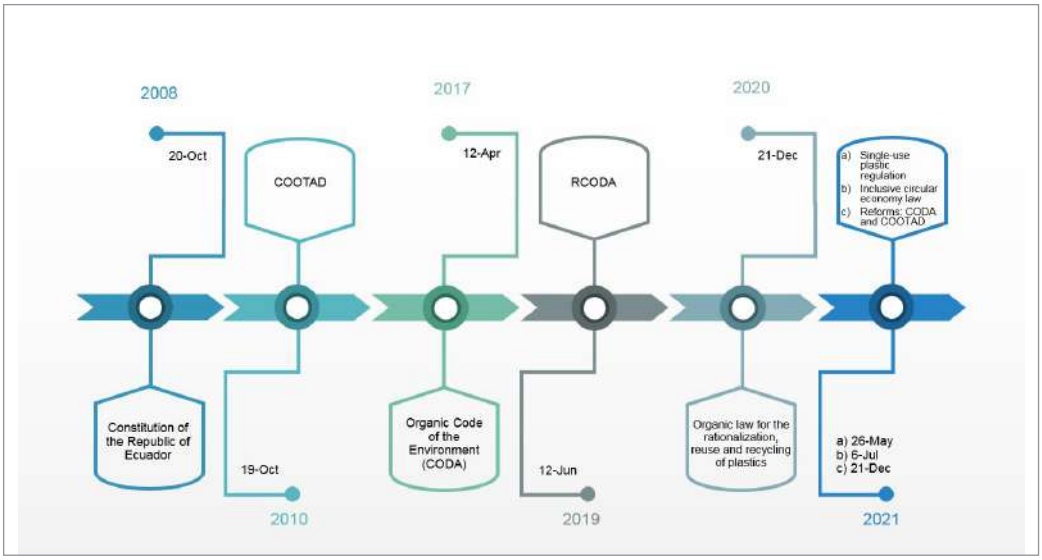
Organic Law for the rationalization, reuse, and recycling of Plastics (Ley orgánica para la racionalización reutilización y reciclaje de plásticos (2020)) is directly focused on single-use plastics with gradually imposed restrictions. Yearly, higher goals (regarding the use of recycled raw material) and prohibitions are established. 1) Gradual advance exception: Protected areas restricted the use/entry of single-use plastics with the issuance of the law, 2) The responsibilities of the GADs are re-established.

Inclusive circular economy law (Ley de economía circular inclusiva (2021)) is a recent regulation established for GADs, especially for industries to follow the responsibilities. Additionally, the rights of the base recyclers are indicated.

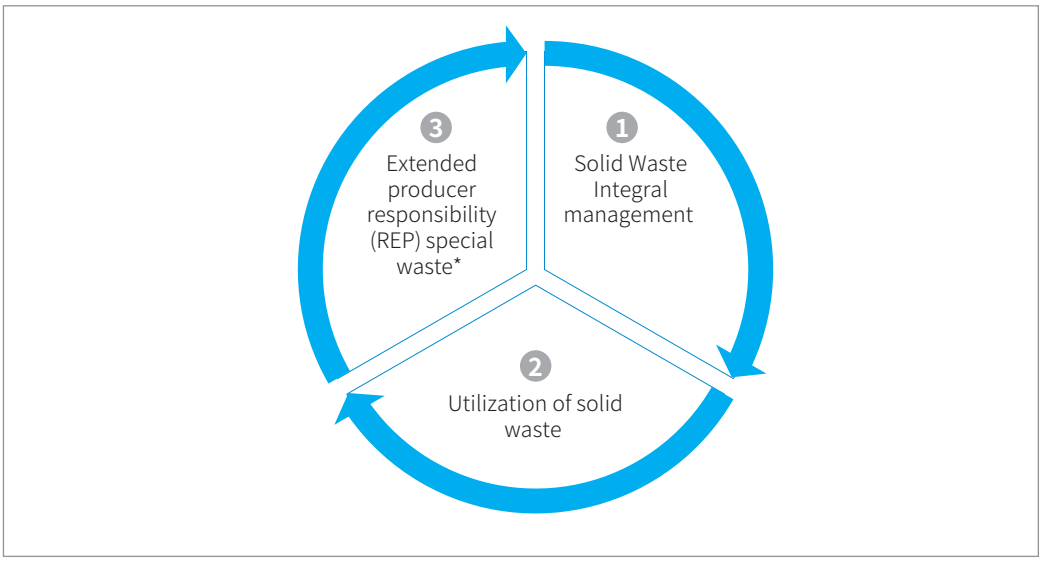
「*Incentives for the industry have been developed within the regulation of this law, which appro*val by the presidency is scheduled for August 2022」.

Secondary regulations will be generated from this regulation. These include 1) National Circular Economy Strategy, 2) List of priority products: priority products are defined as those that originated from mass consumption - (i) Causing more significant environmental impacts and (ii) Do not have treatment. Within this list, specific regulations are contemplated, such as the responsibility extended to the producer and other specific policies where the principles of a circular economy are applied (ecodesign and reuse among others), and 3) Circular economy information system: Information on everything related to the circular economy and will be linked to priority products, compiling information on policies applicable to each one of them.

<Figure 3-5> Timeline of solid waste environmental legislation



<Figure 3-6> Solid Waste Management Cycle



(2) Ministerial Agreements regarding Solid Waste Management

[Table 3-5] Ministerial Agreements on Solid Waste

(1)	• **Ministerial Agreement No. 031 Process for the technical closure of dumps (TULSMA)–2012**: Determines the scope of municipal projects for the technical closure of dumps. • **Ministerial Agreement No. 052 Emerging Cells–2013**: Establishes the alternative for solid waste disposal in emerging cells (1–2 years of operation). In addition, it determined the term of technical closure of dumps until May 2015. • **Ministerial Agreement No. 061 Reform of the Environmental Quality Book (TULSMA)**: Defines the comprehensive management of solid waste.
(2)	• **Ministerial Agreement No. 019 Policies for comprehensive management of plastics in Ecuador - 2014**: Establishes policies for plastics management in Ecuador. • **Agreement 121 Regulation for the management of glass bottle waste in Ecuador - 2016**: Defines the goals of manufacturing glass bottles with recycled raw material.
(3)	• **Ministerial Agreement No. 021 (2013)** : Instructions for the management of plastic waste for agricultural use. • **Ministerial Agreement No. 022 (2013)** : Instructions for the management of used batteries. • **Ministerial Agreement No. 098 (2015)** : Instructions for the management of used tires. • **Ministerial Agreement No. 067 (2022)** : Instructions on extended responsibility in the management of electrical and electronic waste. ** The one who puts the product on the market is responsible for recovering that product when it becomes waste. Actors: Producer (directly responsible), GADs (help/support in the special waste recovery chain)*

(3) Planned regulation to be issued on solid waste and residues

[Table 3-6] Short and mid-term planned regulations

Short-term	Mid-term
• Regulation of the inclusive circular economy law • Reform of the ministerial agreement 098: Instructions for the management of used tires • Ministerial agreement for low documentary waste management • REP regulations for packaging and containers • Regulation of priority products.	• REP debris regulations • Reform of the Ministerial Agreement No. 021 of the Instructions for the Integral Management of Plastic Waste for Agricultural Use • Technical regulations for the design and operation of the phases of integrated solid waste management • Secondary regulations for regularization, control, and environmental monitoring processes • Guidelines and regulations related to the circular economy and inclusive recycling • Integral Solid Waste Management National Plan • National Circular Economy Strategy • National Plan for Single-use Plastics*

** Includes segment on source separation, which is mentioned in several laws but is not being complied with. Issuance of the National Plan is scheduled for late 2023.*

(4) Organic Law for the Rationalization, Reuse, and Reduction of Single-Use Plastics

On December 21, 2020, the Organic Law for the Rationalization, Reuse, and Reduction of Single-Use Plastics entered into effect in Ecuador through its publication in the Registro Oficial, the official gazette. The purpose of the law is to restrict the use of single-use plastic products. This includes 1) An increase in post-consumer recycled material being sought and 2) Definition of biodegradable materials in Ecuador (late 2022): biodegradable within a maximum of 24 months, do not generate microplastics, and are non-toxic.

[Table 3-7] Summary of Organic law for 3R Single-Use Plastics

Chapter I
Overview
• (Purpose) To develop the provisions included in the Organic Law for Rationalization, Reutilization, and Reduction of Single-Use Plastics • (Objective) To reduce single-use plastics available in the national market, encourage a reduction in plastic-waste generation and exploitation through re-utilization and recycling or industrialization; to promote replacing the use of single-use plastics with containers and products that incorporate post-consumption recycled, biodegradable and/or compostable material.

Chapter II

Planning Surveillance and Control

- (*Municipal or metropolitan decentralized autonomous governments planning*) **Municipal or metropolitan decentralized autonomous governments will design the Municipal Plastic Waste Reduction Plan** within 180 days of the announcement of the National Plastic Waste Reduction Plan. **The municipal plan should align with the goals** and objectives of the National Plan and be submitted to the National Environmental Authority for approval, control, and follow-up. The format will be provided by the National Environmental Authority, and any changes to the approved plan should be made within no more than 30 days, with prior notification and justification. The approved Plan will be valid for five years and should be renewed afterward.
- (*Surveillance and control*) The environment governing body will follow up with the achievement of the Municipal Plastic Waste Reduction Plan, which should be submitted for approval within the first 15 days of January, yearly. The production governing body will communicate with productive unions and producer industries to correspond to the law and issue secondary rules to comply with the provisions in the Organic Law for Rationalization, Reutilization, and Reduction of Single-Use Plastics. **Municipal and metropolitan decentralized autonomous governments will be responsible for surveillance and control of policy and action compliance**.

Chapter III

Single-Use Plastic Progressive Reduction

- (*Importing single-use plastics and their residues*) **the governing entity of production will determine the requirements for importing single-use plastic elements and domestic-production plastic elements in terms of percentages and progressiveness, requirements, and regulations for importing raw materials** to encourage the exportation of value-added products. The Foreign Trade Committee (COMEX) will establish the mechanism to activate the import.
- (*Single-use plastic national manufacturing*) Create the mechanisms to control compliance with progressiveness to incorporate the recycled plastic component into single-use plastic products. To keep environmental administrative authorizations effective and active that correspond to the economic activity they perform.
- (*Single-use plastic product reduction and prohibition*) **It is forbidden to give or provide free single-use plastic bags that do not meet the recycled plastic minimum component** outlined in section 11 of the Organic Law for Rationalization, Reutilization, and Reduction of Single-Use Plastics. Moreover, **it is forbidden not to have a certification by the governing entity of production to credit the composition thereof contains the required recycled plastic minimum**.
- (*Recycled-plastic minimum component*) COMEX will define the minimum characteristics regulated products should meet for single-use plastic production, importation, distribution, and marketing in the Ecuadoran market, marketed within the national territory, excluded from the prohibitions defined in the Law, in agreement with the governing entity of the environment, and prioritizing local supply. Additionally, they will observe the minimum percentages of recycled raw materials for each type of residue that they should incorporate progressively into the regulated products.

Product/Temporality	18 months	36 months	48 months
Plastic sheaths	50%	55%	60%
Expanded polystyrene containers	8%	12%	18%
Glasses/tubs	10%	25%	30%
Cutlery	10%	25%	30%
PET bottles	5%	15%	30%

- (*Plastic residue exploitation*) Keep statistic control yearly of local production of recycled raw material and plastic residue recovery and compare it with local demand in such a way that ensures timely and sufficient supply for the plastic industry. Provide an annual report of the progress on achieving the goals outlined in municipal plastic waste reduction approved plans of municipal or metropolitan decentralized autonomous governments, as well as by the non-hazardous solid residue collection site and downstream recyclers existing in the country. The governing entity of production will submit annually a report on statistical control of local production of recycled raw materials to the governing entity of the environment.

Chapter IV

Municipal Metropolitan District Decentralized Autonomous Governments Obligations

Municipal and metropolitan decentralized autonomous governments should consider the following:

1. Submitting an annual report to the national environmental authority for approval on the progress of achievement of the goals in the approved Municipal Plastic Waste Reduction Plan within the first 15 days of January each year;
2. Implementing within their jurisdiction the Municipal Plastic Waste Reduction Plan;
3. Implementing separation in the source and separate collection within the framework of their integral solid residue management
4. Promoting and coordinating with the industrial sector and plastic producing companies post-marketing raw material reincorporation to guarantee the achievement of the goals in the Organic Law for Rationalization, Reutilization, and Reduction of Single-Use Plastics, or this regulation, and of the national plastic waste reduction plan;
5. Entering into agreements with each other to perform integral management of their plastic residue and waste in any phase or adopting a joint management model according to the provisions of the rules in force to minimize environmental impacts and encourage economies of scale;
6. Duly sending the information that may be requested to the governing entity of environment and the governing entity of production, which will verify the information sent through pertinent mechanisms; and
7. Promoting, in coordination with the industrial sector and plastic producing companies, the creation of non-hazardous plastic residue collection sites to contribute to plastic residue collection and separation in the source.

Chapter V

Plastic Residue Exploitation for Industry

- (*Purpose of Exploitation*) **To diminish the amount of plastic residue at final disposal sites, encourage the use of post-consumption raw material, and collaborate in plastic residue recovery management to meet the minimum requirement of post-consumption recycled material for each residue type**, according to Section 11 of the Organic Law for Rationalization, Reutilization, and Reduction of Single-Use Plastics.
- (*Actors*) Plastic residue industrial generators; importers; management agents:
- (*Obligations*)

1. Have adequate facilities available, technically built for plastic residue storage, revaluation, or treatment, equipped with machinery and with their respective environmental administrative authorization, as applicable;
2. Keep a monthly record of the type, amount, or weight and characteristics of the generated or imported, stored, revalued, or treated plastic residues; and an annual consolidated statement will be submitted on January 30 yearly, as well as their verification means of delivery to base recyclers or authorized environmental agents;
3. Sign delivery reception certificates of pre-classified plastic residues for the parties' support; and
4. Establish and propel exploitation and recycling mechanisms of the generated plastic residues at the facilities of their productive activities.

Chapter VI
Awareness and Encouragement for Single-Use Plastic Reduction
• (*Awareness and encouragement*) The governing entity of the environment will determine the strategies, objectives, and goals regarding single-use plastic in the National Plastic Waste Reduction Plan with pertinent institutions. The production and environmental governing bodies will determine the incentives to promote investment in the recycling process, research, and economic activities that involve recycling. • (*Information and labeling transparency*) The governing entity of production with its competent affiliate entities will determine the labeling, control, and compliance, of the amount of recycled material in single-use plastic products. It will provide the technical supplies to the Ecuador national normalization agency to create the rules for labeling plastic items. The labeling system may be internationally homologated, and labeling will be placed in product packaging for products that cannot be identified in each unit. • (*Labeling of products that incorporate post-consumption recycled material*) **For products that incorporate post-consumption recycled, biodegradable, and/or compostable materials, the production governing entity will coordinate with the environment governing entity for proper identification and ensure that the Equador national normalization agency** creates respective technical rules, such as the issuance of carbon footprint to identify these products. • (*Labeling of other products containing plastic components*) Other products containing plastic components should be labeled within 24 months of the Regulation's effective date so that consumers are aware of the negative impact of post-consumption disposal of these products on the environment.
Chapter VII
Producer's Research, Safety Protocols, and Responsibility
• (*Encouragement for research on alternatives to the use of plastics*) The governing entity of the environment will determine strategies, objectives, and goals to encourage research on alternatives to the use of plastic in the National Plastic Waste Reduction Plan. For substitute materials for single-use plastics, the governing entity of the environment will introduce the procedure to submit the product life cycle analysis, which should include at least one substitute product and appear in the labeling. • (*Extended producer responsibility*) **The National Environmental Authority will adopt extended producer responsibility rules and strategies so that manufacturers and importers take action against the environmental damage** caused by inadequate single-use plastic management.

(5) Law of Circular Economy

The law of circular economy, which is aligned with the Constitution of the Republic of Ecuador, was drafted on December 3, 2020, and approved in May 2021. This law aims to establish criteria and mechanisms to implement the principles of a circular economy(A circular economy defined in the law is to reduce the consumption of raw materials, energy and resources by changing the mechanisms of production, distribution and consumption of goods and services, and to maintain the usefulness and value of products and resources for as long as possible) and define the responsibilities of the entities and agencies. It also includes specific criteria and mechanisms aimed at preventing and reducing waste generation and promoting their reuse, recycling, and other types of recovery.

The law is applied to all entities, and its objective is similar to that of other countries, which is to reduce waste generation and maximize the use of generated waste as energy or as a material. To manage wastes, the law stipulates obligations for the actors, such as

government, citizens, and producers, and there are separate obligations for exports and importers, which differ from other countries. The import of waste is limited to raw materials for conversion and materials objectively proven that cannot be supplied domestically.

<Figure 3-7> Contents of the Inclusive Circular Economy Law

Inclusive Circular Economy Law (May 2021)

I. General
- Chapter 1. Objective and Principles
  Article 1~4
- Chapter 2. Definition
  Article 5

II. Institutions and Public Policies
- Chapter 1. Institution
  Article 6~19
- Chapter 2. Public Policies For Social Inclusion
  Article 20~21

III. Sustainable Production
- Chapter 1. Obligations
  Article 22~31
- Chapter 2. Eco-design
  Article 32~33

IV. Sustainable Consumption
- Chapter1 Rights And Duties Of The Citizen
  Article 34~36
- Chapter2 Forms Of Participation Of The City
  Article 37~38

V. Inclusive Management
- Chapter 1. Waste Management
  Article 39~43
- Chapter 2. Inclusive Management in Decentralized Autonomous Governments
  Article 44~47
- Chapter 3. management system
  Article 48~52

VI. Incentives And Financing For The Inclusive Circular Economy
- Article 53~57

VII Audit and Sanctions
- Article 53~59

In the sustainable production part, extended producer responsibility (EPR) for priority products* is indicated. Also, the determination of the priority products subject to extended responsibility of the producer will be conducted through an approved technical standard and will be applied to the categories or subcategories defined in the respective technical instruments issued by the National Advisory Council for the Inclusive Circular Economy.

** Priority Products: Lubricants, electrical appliances, electronic devices and mobile phones, automobile batteries and spare parts, batteries, containers and packaging, tires, telephones, internet, fiber optics and cables, and wiring harnesses for services using postal or underground services, used in the agricultural export industry plastics.*

An Integrated National Registry of Waste Emissions and Transfers System is digitized into a Single Environmental Information System (SUIA) to manage the waste collection, storage, transport, and treatment activities. The producers should report to the system about the type, quantity, costs, origin, treatment, and destination of wastes.

[Table 3-8] Summary of the Inclusive Circular Economy Law

I. General
Chapter 1. Objective Scope, Principles
• (*Objective*) To establish mechanisms for the implementation of the principles of the circular economy. To define the responsibilities of the entities, agencies, and dependencies that comprise the public sector within the framework of the inclusive circular economy • (*Scope*) It applies to all entities and agencies, including the public sector, communities, peoples, nationalities, and groups, which are permanently or temporarily in Ecuadorian territory. • (*Principle*) Coordination and integration, polluters pay principle, efficiency, participation, precaution, preventive, the responsibility of the waste generator, traceability, recovery of residues, etc.
Chapter 2. Definition
• Life cycle of a product: From the acquisition of raw materials or their manufacture from natural resources or secondary materials to their elimination/treatment or final disposal of residing coma and/or waste, respectively. • Waste: Solid, semi-solid, liquid, gaseous, or composite materials resulting from a process of production, extraction, transformation, recycling, and use or consumption, whose disposal or final disposition is preceded under the provisions of the applicable national and international environmental legislation and which is not susceptible to use or recovery. • Circular Economy: inclusive circular economy is understood as the economic model of exchange and production that, in all stages of the life cycle of resources (goods and services), seeks to increase their efficiency, use and value for as long as possible, reducing the production of waste, reducing the impact on the environment, and allowing the well-being of individuals, under an inclusive approach that promotes the incorporation and development of recycling workers or grassroots recyclers ...
II. Institution and Policies
Chapter 1. Institutions
• (*National Circular Economy System*) The system encompasses all organizations, institutions, and resources whose main objective is to articulate the implementation of the National Strategy for an Inclusive Circular Economy and compose the National Committee for Inclusive Circular Economy • (*Attribution*) Establish guidelines and directives for the formulation of technical standards and control and follow-up mechanisms for the progress of national standards. • (*Inclusive Circular Economy Advisory Council*) the operating regulations of the Consultative Council will be determined by its members and must meet at least twice a year. The Advisory Council must issue recommendations on public policies related to the Inclusive Circular Economy • (*Register*) The Integrated National Register of Emissions and Transfer of Waste was managed and digitized through the Single Environmental Information System–SUIA (Producers of priority products; Importers and exports of priority products, Authorized management systems; distributors, traders, or service providers of priority products, where appropriate.)
Chapter 2. Policies for social inclusion
• (*Partnership*) The state will recognize and value the profession of recycler, and autonomous governments seek to encourage the organization of basic recyclers through various mechanisms, such as legal assistance

III. Sustainable Production

Chapter 1. Obligations

- (*Waste importers and exporters*) The import of waste of any kind for its elimination or final disposal is prohibited. In the case of non-hazardous and special waste, the introduction or import will be allowed only and exclusively if it is objectively demonstrated that it cannot be supplied in the country and the following conditions are met: When there is the technical and technological capacity for the use and with them, the adequate environmental management is guaranteed; and to meet the national demand, prioritizing that the availability of non-hazardous waste and special waste generated in the country has been exhausted.
- The export of waste shall be exclusive to materials, which are demonstrated that they cannot be supplied at the national level. The export of waste which can only be disposed of at national level or finally disposed of is permitted.

Chapter 2. Extended Producer Responsibility For Priority Products

- (*Obligations*) Producers should register in the Integrated National Registry of Emissions and Waste Transfer and participate in the collection, storage, transport, and treatment activities
- (*Priority products*) The determination of the priority products subject to extended producer responsibility will be conducted through an approved national technical standard and applied to the categories defined in respective technical instruments issued by the National Advisory Council for the Inclusive Circular Economy.

Chapter 3. Ecodesign

- (*Goods and Services*) companies will progressively incorporate eco-design features to reduce their environmental impact and improve their valuation processes.

IV. Sustainable Consumption

- (*Obligations of consumers*) citizens must separate solid waste from both organic and inorganic at source, houses will have devices for proper and differentiated waste separation and storage;
  - (Obligations of industrial consumers) Industrial consumers must use the waste from priority products they generate and should report to the National Committee on Inclusive Circular Economics. Industrial consumers who generate more waste than setting targets will be penalized.

V. Inclusive Management

Chapter 1. Waste Management

- (*Obligations of waste generators and managers*) Any waste generator should deliver wastes to a qualified manager authorized for their disposal and/or treatment. The management systems will be authorized by the different levels of government, depending on the territorial scope of the system

Chapter 2. Inclusive Management in the Autonomous Government Decentralized

- The National Committee for Inclusive Circular Economics provides national technical parameters and technical support requiring different government levels.
- Decentralized autonomous governments may conclude agreements with management systems for the separation of, selective collection, establishment, and operation of reception and storage facilities
- (*Role*) to collect, manage, and/or dispose of waste and waste unprocessed by management systems; establish arrangements and mechanisms for differentiated collection of waste; authorize the use of soil for the location and operation of waste facilities; to inform and educate effectively about citizens' responsibilities, etc

Chapter 3. Waste System
• Functions of separation at the source, collection, and transportation are indicated. • (*Collective management system*) legal entities whose purpose is managing waste will be constituted and responsible before the authority. These legal entities may include producers, distributors, service providers, base recyclers, and associated managers. • (Individual management system) Waste producers contract directly with authorized and registered managers. • Every management system must report the Integrated National Registry of Emissions and Waste Transfer progress on fulfilling the goals and other associated obligations.
VI. Incentives and Financing for Inclusive Circular Economy
• The system of incentives would be linked to national and local strategies for promoting the circular economy, access to public bank credit, and public policy aimed at promoting the circular economy. The system will be updated annually. • (*Incentives*) the autonomous government can provide tax incentives such as a reduction in a percentage of municipal rates and charges
VII. Supervision, Infractions, and Sanctions
• (*Supervision and Monitoring*) It will correspond to the monitoring established by the National Committee for Inclusive Circular Economy, the audit of compliance with the goals of collection and recovery of waste of each priority product and the associated obligations, as well as the operation of management systems, compliance with information duties and other obligations established in this Law. • (*Sanctions*) in case of minor offenses, the producer or supplier will incur a minor infraction when they do not report or deficiently report the collection and recovery goals and their compliance. In the case of serious offenses, the waste manager as well as the unauthorized producer or legal entity will be sanctioned with a fine corresponding to ten percent of the damage originated , according to the technical audit report. This fine will be imposed without prejudice to the actions that may take place according to the Organic Environmental Code and the others established in the Ecuadorian legal system.

There are two primary organic laws related to waste management or disposal.

First is the “Organic Law of Inclusive Circular Economy” (Ley Organica de Economia Circular Inclusive). In terms of waste management, this law is related to the treatment priority that waste should receive from eco-design, reuse, repair, restore, remanufacture, reduce, re-propose, recycle, and recover energy. This law was published on June 29, 2021

Second is the Organic Law for the Rationalization, Reuse, and Reduction of Plastics (Ley Organica para la raconalizaicon, reutilizacion y reduccion de plastics de un solo uso). This law seeks to regulate the generation of plastic waste, the progressive reduction of single-use plastics, and the reuse and recycling of waste through responsible use and consumption. When possible, its replacement by packaging and products made with recycled material or biodegradable with a lower carbon footprint than the product being replaced contributes to caring for the health and Environment. This law was published on December 20, 2020.

All the activities of the GADM must follow these two laws. Each organic law has a regulation, which is normative for applying the organic law.

Lastly, it is the Ministerial agreement or decree. The Ministerial agreements are a unilateral administrative act imposed by the Ministry for a specific administrative procedure, technical criteria, or Program for determining the issue. For instance, the cases of EPR have been issued by ministerial agreement of the Environment, Water, and ecological transition Ministry.

At the same level, it includes the Ordinances. The cities have approved several ordinances related to waste management. For instance, an Ordinance for the regulation of single/use plastic in the metropolitan district of Quito (April 26, 2021), the Ordinance for the promotion of the circular economy in the city of Guayaquil (April 14, 2021), or the Ordinance that regulates the management of non-hazardous solid waste of recoverable material in the city of Guayaquil (March 9, 2021).

These ordinances are related to normative and obligation to meet a specific issue in the city. The ordinances are regulations expedited by the mayor of the cities in agreement with the municipal committee. All the ordinances must meet the organic laws.

The Environment Ministry also has some projects to support the actions or laws of the Ministry. For instance, The Environment Ministry is currently working on the following normatives and projects: the National Plan of integrated waste management, the National Plan for plastic reduction, the Normative of the plastic waste import, and the regulation of the organic law of inclusive circular economy. It is remarkable that the Environment Ministry also reviews the ordinances and works with the municipality to improve or assist the municipalities in generating an ordinance or public policies.

2. Analysis of the Plastic Industry in Ecuador

The Ecuadorian government, which has a primary-oriented industrial structure highly dependent on agriculture, fisheries, and crude oil, is attempting to transform the industrial structure into manufacturing industry. The plastic industry advancement policy is one of the nine strategic industries. In this context, the Ecuadorian plastics industry has been dynamic in the country's economic development.

For decades, the plastics industry has been developing film to preserve and improve production in the agriculture field or to protect flowers during exportation worldwide. The plastics industry has adapted to solve these problems and improve the social-economic quality of the population.

The Ecuadorian Plastics Association (ASEPLAS) represents approximately 64% of the 600 companies related to the plastic industry. However, the production represents more than 90% of the plastic production in the country. The plastic industry has implemented circular economy policies to fulfill the world's environmental agenda and national regulations. These policies are oriented toward a zero-waste and recycling culture. However, the industry has had several challenges in the past years.

[Table 3-9] Current challenges in the plastics and recycling industries

Restriction of plastic waste import in China	• China tightened regulations on waste imports in 2018, affecting the recycling demand and supply issues. The import restriction has created new opportunities for local Ecuadorian companies, and the laws to promote the use of waste plastic were strengthened during the last three years. • Ecuador now imports plastic waste from other countries to China. The import and export trend changes brought about developments in the Ecuadorian plastic industry, but the related technology and business models should be further improved.
COVID-19	• The use of single-use plastics increased during the pandemic, and local companies expressed concerns about rising resin prices and recycling costs. • The increase of recycling companies contributed to increasing the international resin price. • The government and the private sector should continue to cooperate, considering the unpredictable price fluctuation and the need for planning to respond appropriately.
Consumer education	• Strategic communication between the government, industries, and academia is required • The provision of education on the need for environmental protection, the importance of recognizing what materials are used in products, and the value of recycled materials is needed.
Oil price	• External factors, such as rising oil prices, can provide new opportunities for the industry.
Quality vs. demand	• Plastic waste recycling flow should be stabilized, the recycling quality needs to be improved, and relevant legislation needs further development.

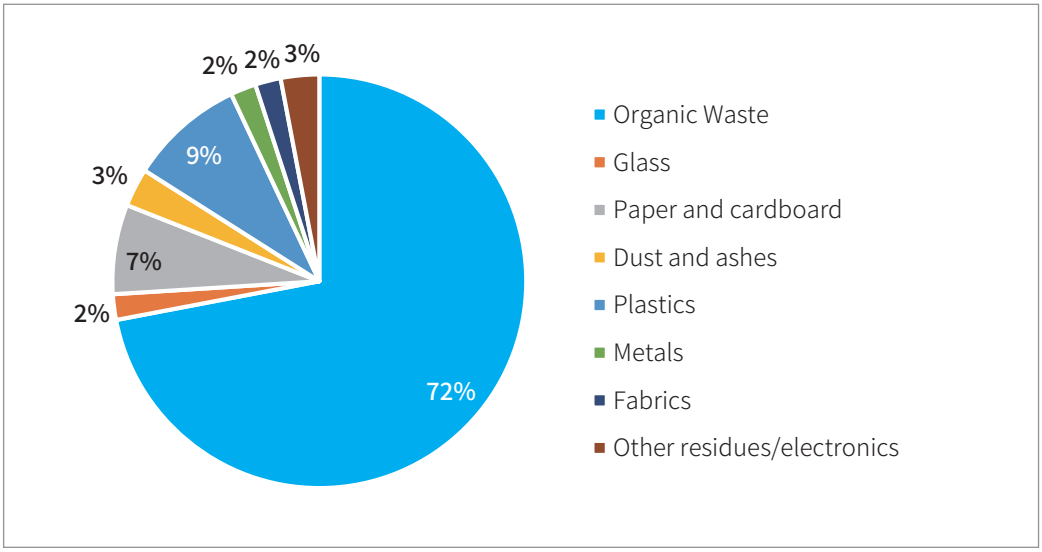
2.1 Plastic Waste Management in Ecuador

Landfills are the most widely used waste disposal method in Ecuador, accounting for 70%, similar to the average in Latin America, while accounting for 25% in Europe and 40% in Mexico. In Ecuador, urban solid wastes (i.e. organic, plastics, cardboard, metal, and paper) follow one stream, having their final disposition in landfills, sub-regulated landfills, open dumps, or unauthorized sites. However, the absence of appropriate waste collection systems is a significant problem in most Latin American countries.

Plastics account for approximately 9% of the common urban waste. Plastic waste generation is approximately 0.31, 0.18, and 0.23 kg/day for low, middle, and high socioeconomic groups, meaning that the number of plastics also depends on several socioeconomic characteristics of the population. Plastic accounts for approximately 9% of the typical urban waste. Plastic waste generation is approximately 0.31, 0.18, and 0.23 kg/day for low, middle, and high socioeconomic groups, meaning that the number of plastics also

depends on several socioeconomic characteristics of the population. In Guayaquil, one of the biggest and most populated cities in Ecuador, the approximate household waste distribution is shown in the figure below. In Guayaquil, one of the biggest and most populated cities in Ecuador, the approximate household waste distribution is shown in the figure below. [51]

<Figure 3-8> Domestic wastes in the city of Guayaquil

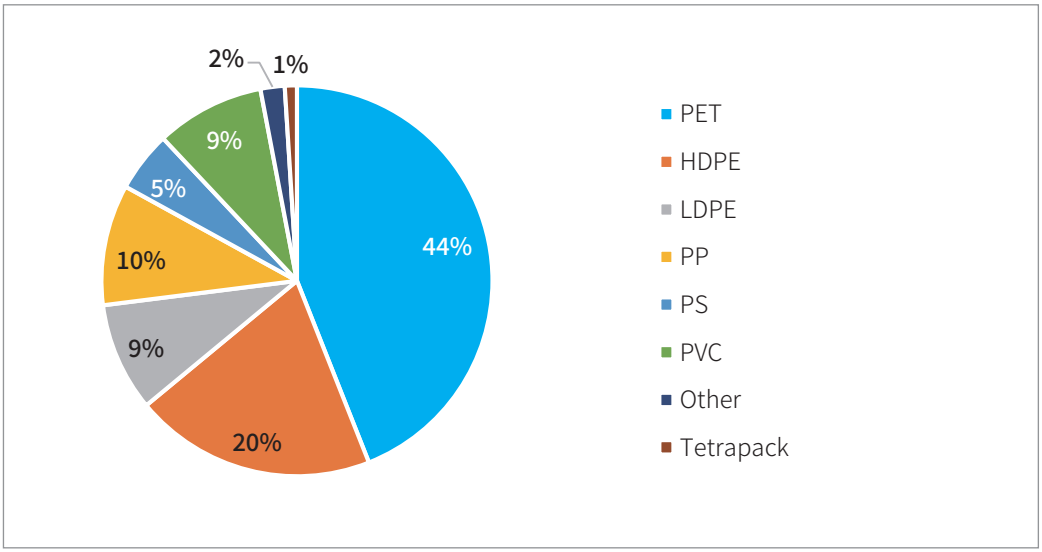


Source: Domestic Plastic Waste in the city of Guayaquil: Generation Rate and Classification (J. Hidalgo-Crespo, et al., 2021)

The distribution of domestic plastic waste in the following graph shows that PET takes up to 44% of the plastic waste stream. Accordingly, the PET recycling industry is highly developed in the country, with companies like Enkador, Intercia, and Reciplásticos that export r-PET flakes and r-PET pellets food grade. Since informal collectors mainly drive the recycling sector, they sort plastics in streets, trash bins, or open dumps, selecting the highly demanded plastics that are better-paid and in larger volumes.

51 Hidalgo, J., Amaya, J., Soto, M., & Caamaño, D. (2021). Domestic Plastic Waste In The City Of Guayaquil: Generation Rate And Classification. https://doi.org/10.18687/laccei2021.1.1.265

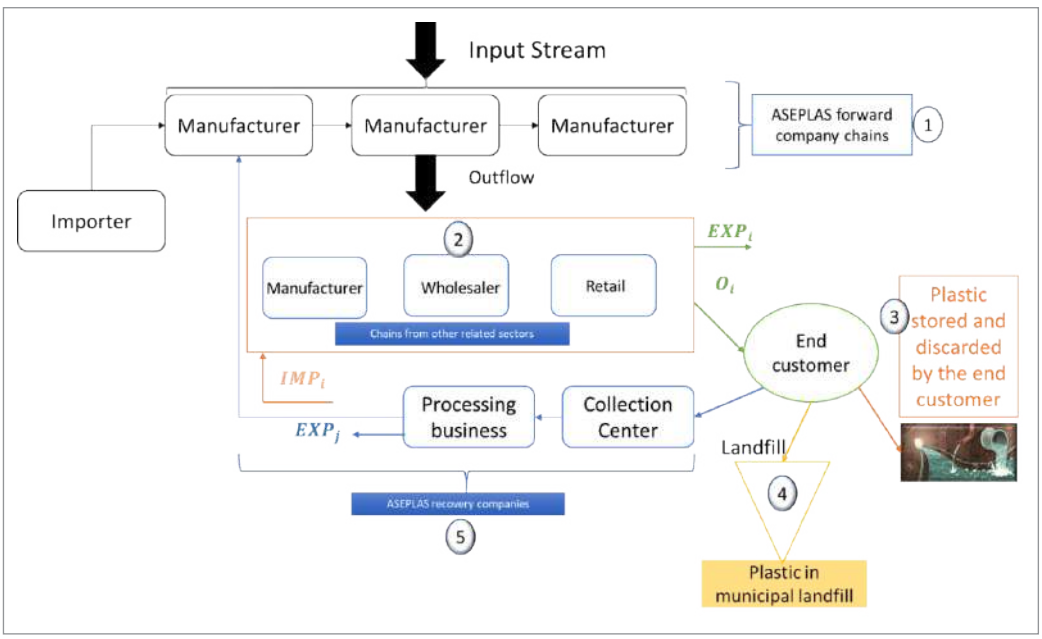
<Figure 3-9> Domestic plastic waste by the type of plastic material in the city of Guayaquil



Source: Domestic Plastic Waste in the city of Guayaquil: Generation Rate and Classification (J. Hidalgo-Crespo, et al., 2021)

The private sector primarily leads the recycling business in Ecuador, and its role in incorporating plastic waste back into the production line is key to moving forward to a circular economy. Other actors are the local governments, who control the waste management and the final consumer.

<Figure 3-10> Stakeholders of recycling business in Ecuador

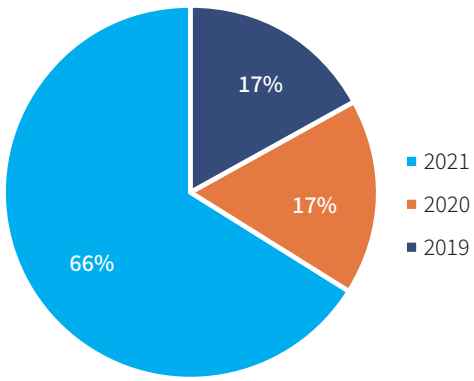


Source: ESPOL (Accessed March 2022)

2.2 Export and Import Status

The last three years have achieved high-speed growth in the exportation of plastics in Ecuador. The number of exported products has varied over time. ASEPLAS collected and provided detailed information regarding the past three years.[52] According to the graph, exports corresponding to 2019 and 2020 were approximately 97.5 tonnes yearly, achieving 34% of total exports in the last three years. It was during 2021 that exports grew to a larger percentage of 376 tonnes. This means that the number of exported products in 2021 was higher than in previous years.

<Figure 3-11> Exportations of Plastics in total (2019–2021)



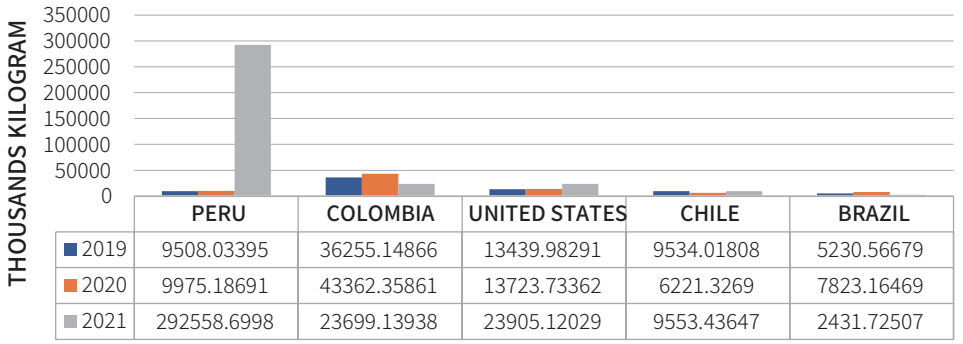
Year	Total(kg)
2019	97,556,376.43
2020	97,538,014.41
2021	376,143,838.70

Source: ASEPLAS (2022)

Currently, the country exports different types of plastic resins. During the last three years, the plastic market has managed to export plastics to several countries in Latin and Central America. Figure 27 indicates that Peru, Colombia, the US, Chile, and Brazil are the top five countries importing plastics from Ecuador. The overall amount of plastic exportation in 2021 had dramatically increased, particularly in Peru, compared with 2019 and 2020. Since Latin and Central America, especially Peru and other countries, are the main strategic exporting countries, the Ecuadorian government and plastic industries should understand their exportation status and prepare to accelerate the plastic industry of Ecuador.

52 Ecuadorian Plastics Association (ASEPLAS). (2020). Economía Circular: Un modelo de crecimiento. *Integra*, 60

<Figure 3-12> Top 5 countries exporting plastics from Ecuador (2019–2021)

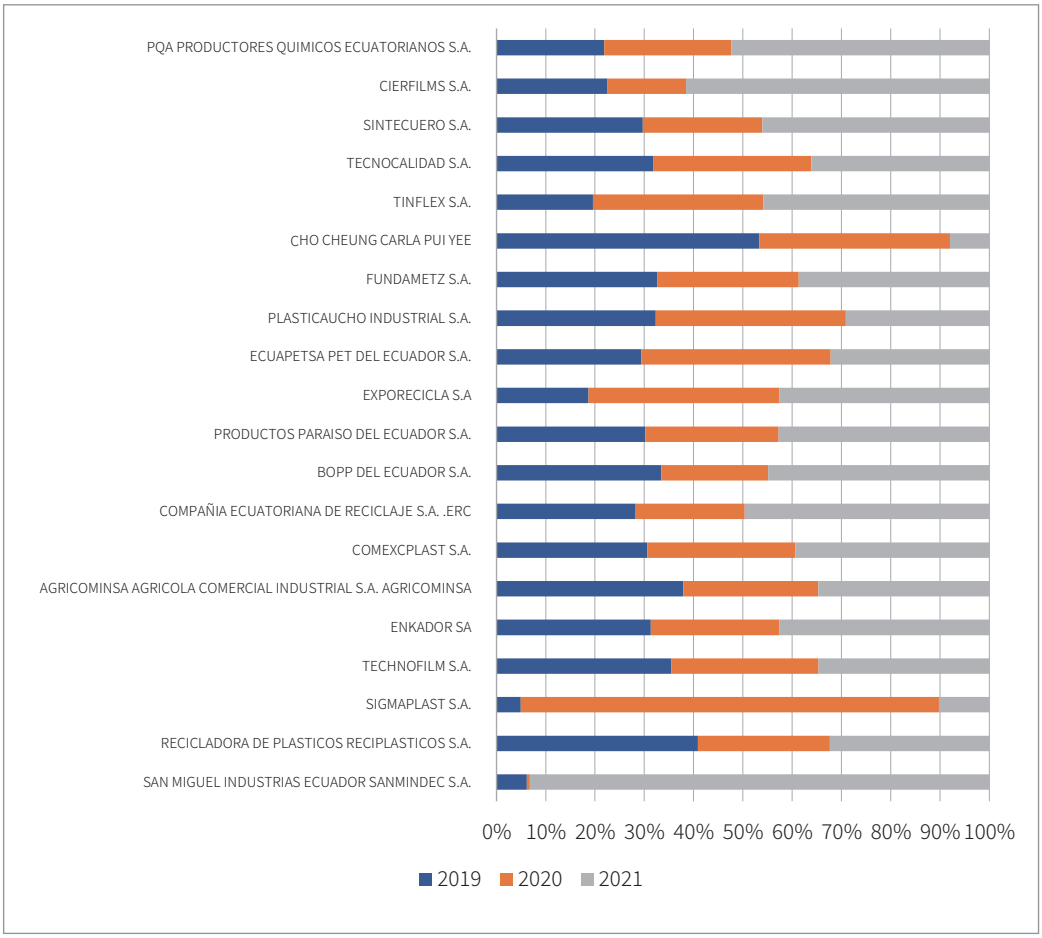


	PERU	COLOMBIA	UNITED STATES	CHILE	BRAZIL
2019	9508.03395	36255.14866	13439.98291	9534.01808	5230.56679
2020	9975.18691	43362.35861	13723.73362	6221.3269	7823.16469
2021	292558.6998	23699.13938	23905.12029	9553.43647	2431.72507

Source: ASEPLAS (2022)

Figure 28 shows the top 20 exporting companies' exportation of plastics divided by years. Companies, such as SANMIGIEL S.A, SUNCHODESA, and PQA, have more than 50% of their total exports concentrated in 2021, while other companies, such as RECIPLASTICOS and CHO CHEUNG, had more than 40% of their exports in 2019. Finally, some companies, such as SIGMAPLAST, EXPORECICLA, and PLASTICACUCHO, concentrated a large part of their exports in 2020.

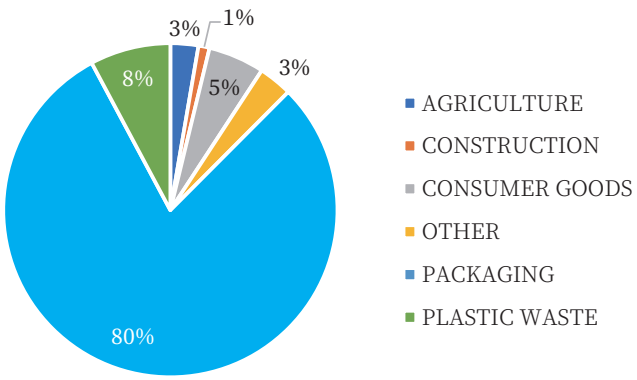
<Figure 3-13> Companies exporting plastics to the top five countries (2019–2021)



Source: ASEPLAS (2022)

Figure 3-13 shows that the largest plastic exporting industry is packaging with a large percentage of 80%, followed by plastic waste at 8% and consumer goods at 5%. In comparison, the smallest is construction with only 1% corresponding to the total exports. The number of plastics exported by each industry during 2019, 2020, and 2021 can be better visualized in the graph below. Conversely, other types of plastics represent 3%, a higher percentage than construction and almost the same as agriculture.

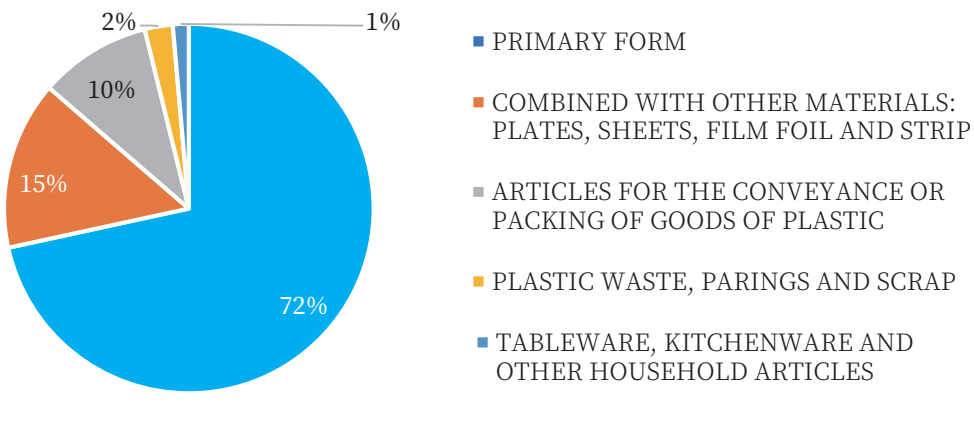
<Figure 3-14> Plastics exported by the industry



Industry	Total(kg)
Packaging	138810499
Plastic waste	13591509
Consumer Goods	9466019.14
Other	5674231.58
Agriculture	4706733.93
Construction	1868451.62

Source: ASEPLAS (2022)

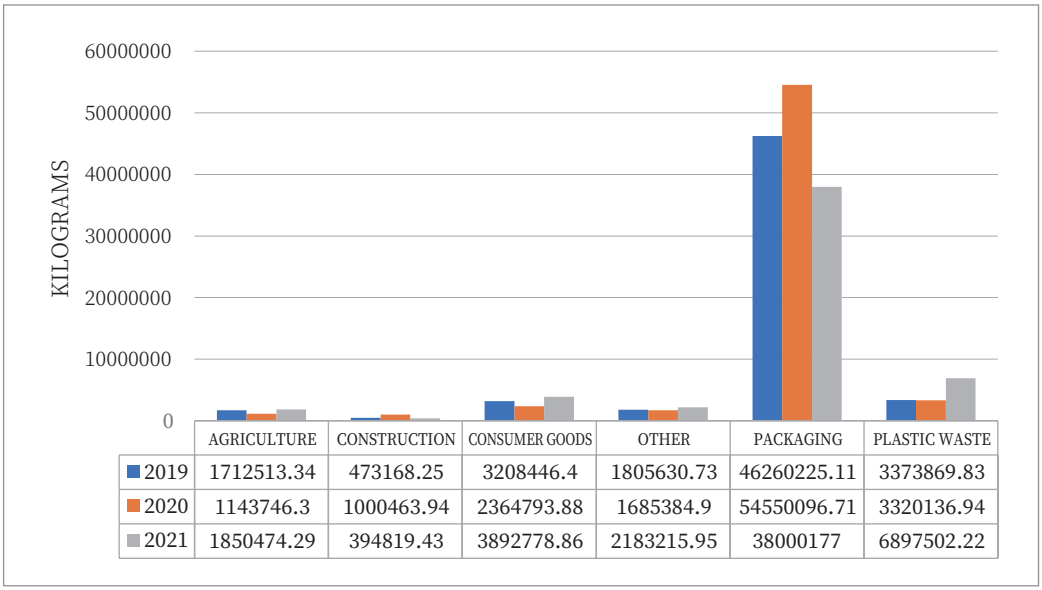
<Figure 3-15> Top Five Industry Exportations



Goods	Total (kg)
Primary form	397120785
Combined with other materials: plates, sheets, film foil, and strip	81844006,3
Articles for the conveyance or packing of goods of plastic	54393201,8
Plastic waste, parings, and scrap	13591509
Tableware, kitchenware, and other household articles	7717519,1

The five most exported goods are primary form with 72% of total exports, followed by other materials: plates, sheets, foils, and strips with 15%. As can be seen, the primary form is almost five times greater than its successor. The remaining percentage is occupied by articles for transporting or packaging plastic goods, waste, trimmings, and scrap of plastic, tableware, kitchen utensils, and other household items.

<Figure 3-16> Top Five Exported Goods in Ecuador



	AGRICULTURE	CONSTRUCTION	CONSUMER GOODS	OTHER	PACKAGING	PLASTIC WASTE
2019	1712513.34	473168.25	3208446.4	1805630.73	46260225.11	3373869.83
2020	1143746.3	1000463.94	2364793.88	1685384.9	54550096.71	3320136.94
2021	1850474.29	394819.43	3892778.86	2183215.95	38000177	6897502.22

Source: ASEPLAS (2022)

Plastics are much less exported to other industries. From 2019 to 2021, plastics were exported the most to the packaging industry. Compared with 2019 and 2020, the amount of exported plastics to the packaging industry decreased significantly in 2021. For the plastic waste and consumer goods industry, the amount of export increased in 2021 compared with 2020. Plastics were exported the least to the construction industry during the past 3 years.

[Table 3-10] Exportations by End-use in Ecuador

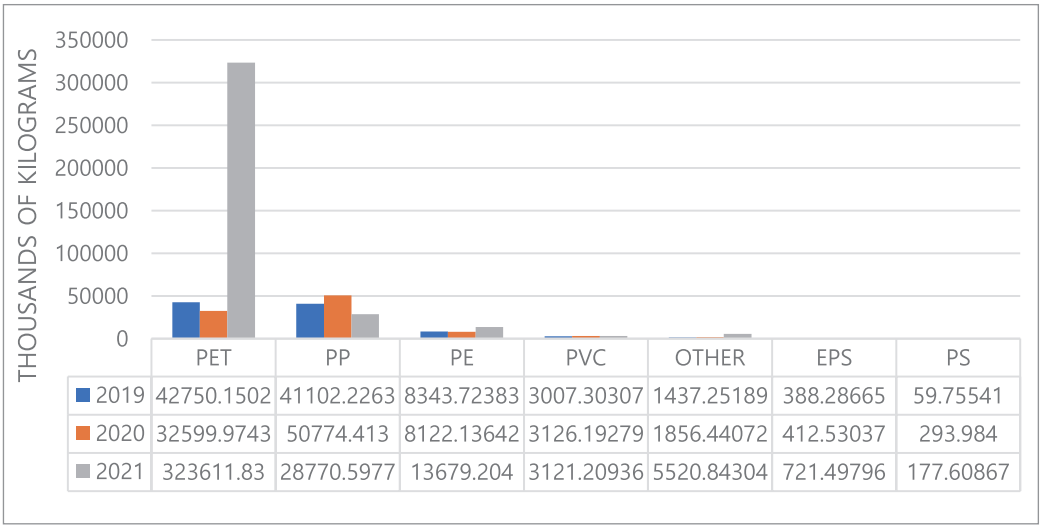
END-USE	2019	2020	2021
PRIMARY FORM	40722,5228	33473,3917	322924,871
COMBINED WITH OTHER MATERIALS: PLATES, SHEETS, FILM FOIL, AND STRIP	16212,9723	44010,8224	21620,2116
ARTICLES FOR THE CONVEYANCE OR PACKING OF GOODS OF PLASTIC	29512,6101	10072,9949	14807,5969
PLASTIC WASTE, PARINGS, AND SCRAP	3373,86983	3320,13694	6897,50222
TABLEWARE, KITCHENWARE, AND OTHER HOUSEHOLD ARTICLES	2549,16937	1818,02451	3350,32522
OTHER	1805,63073	1685,3849	2183,21595

END-USE	2019	2020	2021
PLASTIC PLATES, SHEETS, FILM FOIL, AND STRIP	1532,59569	1115,88585	1657,86418
SELF-ADHESIVE PLATES, SHEETS, FILM FOIL, TAPE, AND STRIP	0,5346427	0,46627942	1,57236853
SANITARY PLASTIC WARE	659,27703	546,76937	542,45364
TUBES, PIPES, AND HOSES	233,77995	724,31856	242,6668
BUILDERS' WARE	228,04004	276,14538	130,89279
MONOFILAMENT: RODS, STICKS, AND PROFILE SHAPES	179,91765	27,86045	192,61011
FLOOR COVERINGS	11,34826		21,25984

Source: ASEPLAS

Table 3-10 shows in detail the number of exported products and confirms that the most exported product is the primary form, especially in 2021. The products not within the top five have a minimum export rate. For example, products like plastic plates, sheets, and film foils, had a low export amount in the three years. The same occurs with tubes, pipes, and hoses, or for sanitary plastic wares. Floor coverings were the least exported.

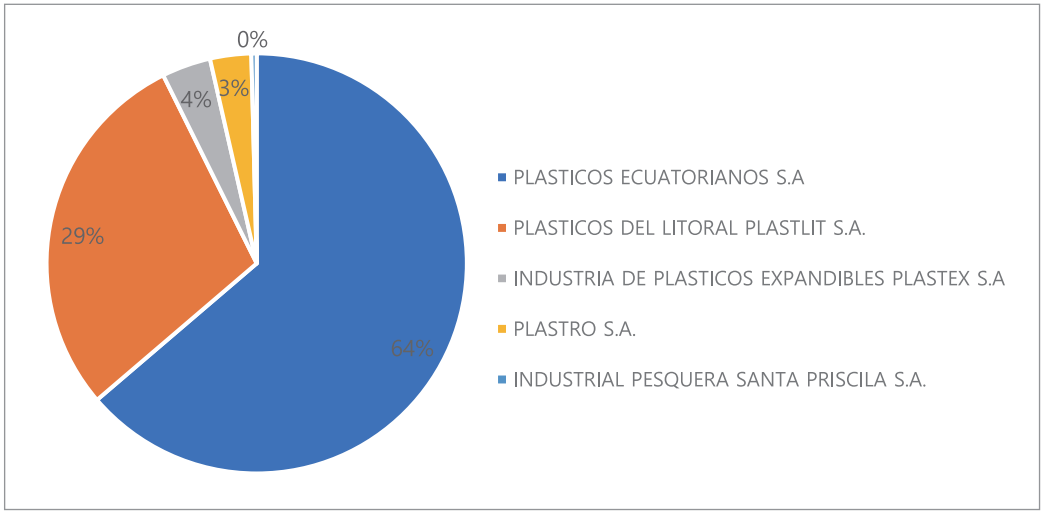
<Figure 3-17> Exportations of Polymer Environmental Resin material in Ecuador (2019–2021)



In 2019, PP was exported in almost the same amount as PET. By 2020, PP became the most exported plastic in the country, with a figure close to 500000000 tonnes yearly, leaving PET as the second. By 2021, PP exports decreased by almost half, while PET exports increased to over 300000000 tonnes.

PE was the third most exported plastic product during the three years, followed by PVC, leaving at the end materials, such as EPS and PS, that are exported in minimal quantities. The same happens with the other types of plastic materials whose export increased in a minuscule way in 2021.

<Figure 3-18> Top Five EPS Exporting Companies in Ecuador



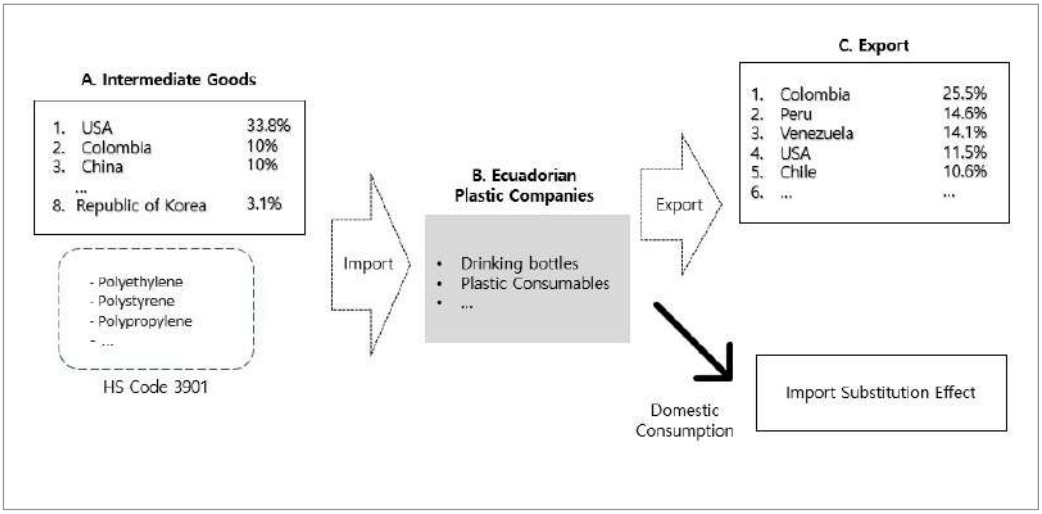
Source: ASEPLAS

COMPANY	Total (kg)
PLÁSTICOS ECUATORIANOS S.A	929014,84
PLÁSTICOS DEL LITORAL PLASLIT S.A	421549
INDUSTRIA DE PLÁSTICOS EXPANDIBLES PLASTEX S.A	54860
PLASTRO S.A	46145,57
INDUSTRIA PESQUERA SANTA PRISCILA	5947,57

Among the companies exporting EPS, “Plásticos Ecuatorianos S.A.” is the highest with 64% (929014,84 kg), followed by “plásticos del litoral” (PLASTILIT S.A.) with 29% (421549,63), while “PLASTEX S.A.” and “PLASTRO S.A.” accounted for the remaining 7% (54860 and 46145,57 kg, respectively). These four companies represent the total EPS export market in Ecuador. INDUSTRIA PESQUERA SANTA PRICILA has an almost null export percentage (5947,57).

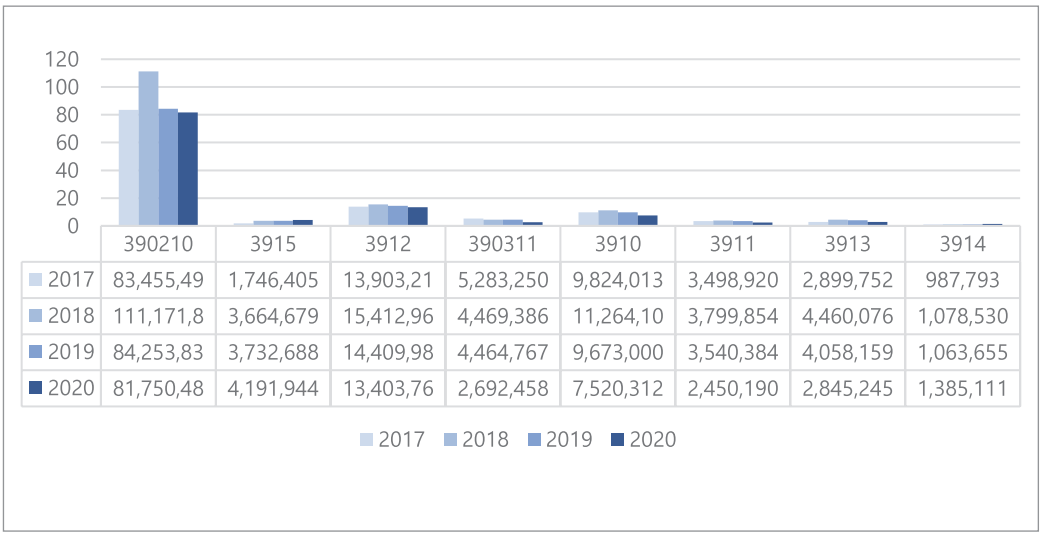
2.3 PP and EPS Analysis of Imports and Exports

<Figure 3-19> Process of Imported Plastics in Ecuador



This figure shows how intermediate plastic goods are imported to the Ecuadorian plastic companies and exported to other countries. Most series of the Polys; HS Code 3901, are the main plastic products imported as intermediate goods. When imported to Ecuador, Ecuadorian plastic companies buy these plastic goods and recycle them via regranulation. When the treatment process is completed, these regranulated plastics are exported to neighboring countries.

<Figure 3-20> Imported Plastics sorted by Trade Value (USD) in Ecuador (2017–2020)



	390210	3915	3912	390311	3910	3911	3913	3914
2017	83,455,49	1,746,405	13,903,21	5,283,250	9,824,013	3,498,920	2,899,752	987,793
2018	111,171,8	3,664,679	15,412,96	4,469,386	11,264,10	3,799,854	4,460,076	1,078,530
2019	84,253,83	3,732,688	14,409,98	4,464,767	9,673,000	3,540,384	4,058,159	1,063,655
2020	81,750,48	4,191,944	13,403,76	2,692,458	7,520,312	2,450,190	2,845,245	1,385,111

Source: UN Comtrade Data (Accessed in 2022)

Among the eight types of Plastics that Ecuador imports, HS Code 390210 (Propylene, other olefin polymers; polypropylene in primary form), HS Code 3910(Silicones in primary forms), HS Code 3912 (Cellulose and its chemical derivatives, n.e.c. or included, in primary forms), and HS Code 390311 (Styrene polymers; expansible polystyrene, in primary forms) are the essential portion of imported plastics. Especially, HS Code 390210 (Polypyrene) is one of the most imported items, with an average of $90 million from 2017 to 2020.

[Table 3-11] Top five countries, Ecuador imports PP and EPS in total (2017–2020)

Country	Qty	Trade Value(USD)
Brazil	79,357,576	87,891,165
Colombia	57,690,006	65,656,172
Chile	54,768,177	64,538,767
USA	26,674,276	39,795,027
India	19,338,427	23,316,895

Source: UN Comtrade Data (Accessed in 2022)

Poly Propylene (PP) and Expanded Polystyrene (EPS) were sorted as HS Codes 390210 and 390311, respectively. The table above indicates the average trade value and scale from 2017 to 2020 in the five countries where Ecuador's Polypropylene (PP) and Expanded Polystyrene (EPS) imports are the most active. The four-year import volume is about $85 million, with imports from three South American countries, Brazil, Colombia, and Chile, accounting for 64%.

[Table 3-12] Top five countries, Ecuador exports PP and EPS in total (2017–2020)

Country	Qty	Trade Value(USD)
Guatemala	10,871,478	8,977,684
Colombia	6,075,738	5,861,073
Panama	147,318	512,635
Spain	809,127	452,731
Peru	324,622	276,991

Source: UN Comtrade Data (Accessed in 2022)

2.4. Polypropylene (PP) and Expanded Polystyrene (EPS)

(1) Polypropylene (PP)

Polypropylene (PP) is one of Ecuador's highly demanded raw materials in manufacturing automobile components, plastic containers, pipes, and building materials. Moreover, it is used for toys and food containers because it is 100% recyclable and manufactured in a non-toxic transparent form. Recently, PP has replaced the EPS for single-use containers. This trend is observed in local businesses and supermarkets. So, PP can be included as a single-use material. The Ecuadorian plastic industry imports polyethylene, polystyrene, polypropylene, and PVC. Moreover, these are raw materials for producing beverage bottles or plastic consumables by simple injection and molding. The Ecuadorian government recognizes the plastic industry as a strategic area and has implemented policies to foster it.

Polypropylene is a raw material that regularly lacks supply, and due to unstable supply, local buyers eventually place more importance on a stable supply line than on price. Since there are no local polypropylene producers in Ecuador, they rely on imports. Large plastic injection molding factories directly import and use polypropylene, whereas small and medium-sized factories receive goods from importers specializing in plastic raw materials. Additionally, when polypropylene supply is unstable internationally, large factories directly import raw materials from local importers. Brazil, Colombia, and Chile account for 70% of Ecuador's polypropylene supply because these products have poor quality but stable supply.

(2) Expanded Polystyrene (EPS)

One study on life cycle analysis concludes that in producing 1.716g EPS, 87.47mg CO_2 is released[53]. Expanded polystyrene (EPS) is the material of choice in several food packaging applications, cost-effective and energy-efficient insulation in construction applications, and cushion transport packaging material for shock-sensitive goods. EPS is a thermoplastic foam product with a unique combination of qualities. It is lightweight, strong, durable, with shock absorption, insulating properties, and excellent processability. As EPS is 98% air, it adds very little weight to packaging and minimizes fuel emissions during transportation. A durable and highly efficient thermal insulator is frequently used in the construction of buildings, thereby reducing the amount of energy needed to heat and cool our homes.

EPS has been traditionally used in food containers, especially in fast food services. The

53 Hidalgo-Crespo, J., Jervis, F., Moreira, C., Soto, M., & Amaya, J. (2020). Introduction of the circular economy to expanded polystyrene household waste: A case study from an Ecuadorian plastic manufacturer. *Procedia* CIRP, 90, 49–54. https://doi.org/10.1016/j.procir.2020.01.089

affordable cost of the EPS containers appears as the best choice in low-income communities since the food price does not increase due to the plastic container cost. Even the EPS containers have always been preferred in sectors with low sanitary levels when water supplied is reduced, or it has been a cultural custom to prefer EPS containers to other income levels.

2.5. Best practicing examples

(1) FADESA

This company manages its environmental impacts through objectives focused on rationalizing natural resources, reducing greenhouse gas emissions, and minimizing waste generation. Regarding the minimization of its waste, we highlight that 95% of the scrap generated from its plastic packaging production (waste from the production process) is recovered by grinding and reentering as part of the raw material without affecting the final product's quality.

Non-recoverable scrap (0.5%) is sold to customers who incorporate it into their processes in other recovery models. FADESA has implemented a circular product design model in its packaging production. They manufacture buckets and blown packaging with recycled resin, whose composition varies from 10% to 50%. None of these containers are used for food.

FADESA's sustainable agenda also involves people: its employees and community. In 2019, it joined the KFC campaign called "Tapatón" promoting the recycling of plastic lids among its collaborators. Their next challenge will be to use recycled resin in 100% of non-food products, thus strengthening the circular economy strategy in the business.

(2) EXPLAST

Explast is a plastic packaging production company that is tangible proof of converting a vision into a circular business today. Based on a "zero waste" philosophy, it has implemented several initiatives to develop a circular waste management model for its value chain. Within its facilities, it makes the most of the waste from its production processes, collecting even the most negligible waste and reusing it to produce secondary packaging, plastic garbage bags, nursery, and other materials.

Additionally, the company has been conducting waste management campaigns with its customers for several years, reaching agreements for collecting and paying for this waste,

which Explast converts into raw materials to produce specific packaging. It also promotes its circular economy philosophy among its customers, advising them on the type of packaging to use for their products.

The remaining waste is converted into pellets and donated to the Rostro de Cristo Foundation in Durán, which manufactures furniture for communities living in conditions of poverty and exclusion. It aspires to continue contributing to the future of circularity in Ecuador. The next challenge is to set up a plant to manufacture products with 100% post-consumer material.

<Figure 3-21>Environmental guide for Explast

Source: Environmental guide. Industrias Plásticas comprometidas con el medio ambiente. ASEPLAS (2021)

(3) PLASTIGOMEZ

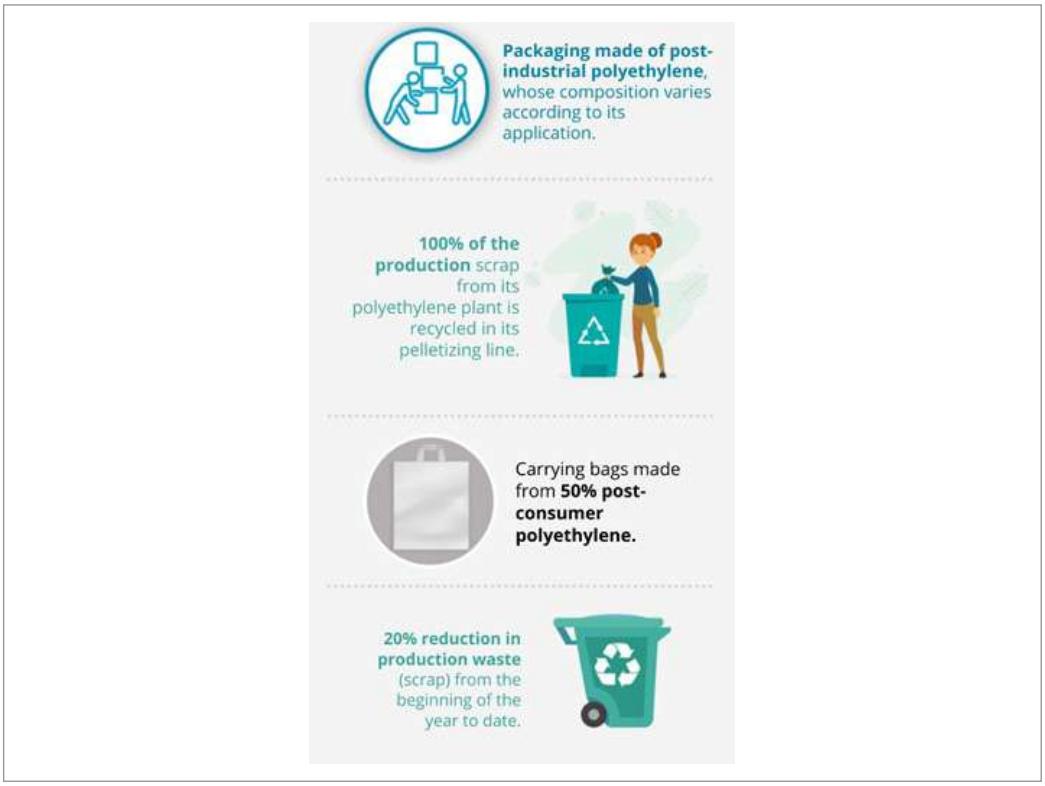
Plastigomez is dedicated to producing flexible plastic packaging. To ratify its commitment to the environment and the circular economy, it has taken actions, such as incorporating packaging made with post-consumer polystyrene in its non-food products. Another measure presented is collecting 100% of the waste generated in the plant, which will be treated in its pelletizing line. Additionally, they have reformed their production line to reduce waste

generation by 20%.

As an inclusive initiative, they have proposed a project to collect polyethylene waste from their clients for reprocessing at Plastigomez.

Among its main actions because of the commitment to be a sustainable company that cares about the environment include energy efficiency projects, the inclusion of recycling entities in the management of collection and reprocessing, acquisition of a second pelletizer, and improvement of equipment and machinery for production.

<Figure 3-22> Plastigomez circular economy actions



Source: Environmental guide. Industrias Plásticas comprometidas con el medio ambiente. ASEPLAS (2021)

(4) PLASTICONSUMO

Among the ecological measures of PlastiConsumo is the production of its covers with post-consumer recycled material with a composition between 50% and 100%. This measure was adopted before the Organic Law for the Rationalization, Reuse, and Recycling of Plastics in Ecuador was enacted.

In what corresponds to the circular economy, it promotes the recycling of post-consumer plastic covers through dissemination in digital media and advertising on its products. It also has a group of collectors dedicated to recycling plastic covers for future treatment, thus promoting and participating in social and economic inclusion and generating indirect jobs.

<Figure 3-23> Plasticonsumo circular economy actions

Source: Environmental guide. Industrias Plásticas comprometidas con el medio ambiente. ASEPLAS (2021)

(5) PICA

Pica is a company committed to Ecuadorian society and the planet and supports its sustainable agenda through various projects:

[Table 3-13] Pica Sustainable Projects

BIOSTYLE LINE	Articles incorporating wheat fiber in their composition, thus reducing the amount of plastic resin required for the manufacture of these products without affecting their quality and with total safety for consumers. Materials are 100% recyclable and BPA-free. This technique is used to manufacture various products such as baking trays, chopping boards, cutlery holders, and bowls.
RENOVA LINE	A wide range of articles is produced with a high percentage of recycled material, which is appropriately additivities to guarantee its quality and the excellent performance of the product.
RECYCLABLE MATERIALS	Pica manufactures products with a long life, which reduces the need for and uses recyclable resins, allowing them to be reintroduced into production processes.

3. Recycling Technology

3.1 Latin America

The recycling capacity and technologies applied globally are related to the country's GDP or levels of development. The EU has mechanical recycling as the first option. Energy is then used when plastics cannot be recycled. Several projects related to chemical recycling have been started in Europe and the US. Asia is also related to these recycling processes. Latin America is related to mechanical recycling. Despite the technology, the key is the collection of plastic waste. The EU is leading the appropriate collection of plastic waste. Latin America has two main ways of plastic waste collection: home collection and drop-off collection centers. Although it has a very high level of collected waste at approximately 85%, the landfill persists as 69% of end-life plastics waste method.[54] Only 4.5% corresponds to waste managed for recycling infrastructure (like those data of South Asia). Private companies in Latin America have managed mechanical recycling. However, the informal sector is extensive and active. The informal sector is part of the chain of plastic waste distribution to some private companies. Besides this situation, there is a continuous effort to recycle and reuse single-use plastics, including EPS.

(1) EPS recycling technology

The recycling of expanded polystyrene is usually conducted in developed countries. Consequently, most of the EPS wastes in Latin America end up in landfills. The recycling of this product can usually be done using the following techniques:

[Table 3-14] Recycling Technologies

Type of treatment	Technique
Primary	Manual
	Mechanic
Secondary	Agglutination
Tertiary	Toluene
	Benzene
Tertiary	Chloroform
	Tetrahydrofuran
	D-limonene
	P-comeno
Quaternary	Energy production

Source: (Arthuz-López & Pérez-Mora, 2019)[55]

54 *Plastic Waste Management and Leakage in Latin America and the Caribbean*. (2020, July). Cleiman. | https://cleiman.com/dev/wp-content/uploads/2020/11/IDB-report-25-2.pdf (accessed March 7, 2022)

55 Arthuz-López, L., & Pérez-Mora, W. (2019). ALTERNATIVAS DE BAJO IMPACTO AMBIENTAL PARA EL RECICLAJE DEL POLIESTIRENO EXPANDIDO A NIVEL MUNDIAL. *Informador Técnico*. https://doi.org/10.23850/22565035.1638

The countries in which this material is usually recycled are as follows:

[Table 3-15] EPS Recycling Technologies by the countries in Latin America

Mexico	Although primary and tertiary recycling techniques are used in Mexico, primary recycling predominates. Rennueva technologies and the companies Dart and Marcos & Marcos, developed a plan that establishes procedures for the correct and responsible management of EPS in any part of the country[56]. The process these companies use for recycling EPS consists of four steps: • Collection: Here, post-consumer EPS (cups, plates, disposable items, and construction waste) is received from individuals, neighboring companies, residents, educational institutions, and municipal and state governments Densified: The material passes to the thermo-densifying machine, where, through heat, the air is extracted from the EPS using heat. Blocks of 20 kg are equivalent to 7,500 cups are produced. • Transformation to raw material: The block undergoes a milling and extrusion process. After this, the result is raw material beads or pellets. • Manufacture of new products: These pellets are used to manufacture new products that do not have contact with food and/or beverages. The new products can be CD cases, shoe soles, rulers, plastics for phones, car moldings, and facings.
Colombia	Biocírculo is a plastic processing company that joined Cootrama, a recycling corporation (EPS) in Colombia. Together with approximately 20 companies, they managed to recover wax from 200 tonnes of EPS in 2021 and sent it to the company Darnel Colombia to be used in the manufacture of new products[57]. They usually use primary recycling to recycle EPS, although tertiary recycling is also available. Both processes are detailed below[58]: **Chemical recycling** 100-g EPS are mixed with 200-ml toluene to obtain a liquid mixture, which is homogenized and packaged in a volumetric container to be evaporated in an oven at 30°C for 24 h. **Mechanical recycling** It uses a thermal-mechanical recycling machine fed with Expanded Polystyrene (EPS) material that has reached the end of its useful life to grind and crush it. This product was passed through a special extruder to melt it, thus obtaining a solid mass without a blowing agent that increased its density. It is necessary to cool the material to room temperature by filling containers in the form of 5-kg rectangles. Conversely, a milling process (sieving) is performed after cooling the rectangles to obtain a determined granulometry.

56 *Presentan Plan Nacional de Manejo de Residuos de EPS (unicel) | Plastics Technology México*. (n.d.). | https://www.pt-mexico.com/noticias/post/presentan-plan-nacional-de-manejo-de-residuos-de-eps-unicel (accessed March 16, 2022)

57 *Reciclaje en empresas colombianas , reutilización de 200 toneladas de Icopor al año | Empresas | Negocios | Portafolio*. (n.d.). | https://www.portafolio.co/negocios/empresas/reciclaje-en-empresas-colombianas-reutilizacion-de-200-toneladas-de-icopor-al-ano-559833 (accessed March 16, 2022)

58 Peña, C,, Humberto Quintero. Reciclaje termo-mecánico del poliestireno expandido (ICOPOR), como una estrategia de mitigación de su impacto ambiental en rellenos sanitarios. *Informador Técnico*. 2015;79(2):81-84. https://www.proquest.com/scholarly-journals/reciclaje-termo-mecánico-del-poliestireno/docview/1806094431/se-2

Brazil	Brazil has a recycling volume of 838 thousand tonnes of post-consumer plastic annually and a census of 695 recycling companies. About 34.5% of all EPS produced is recycled annually, a rate equal to that of more developed countries. Knauf is a Brazilian company that seeks to contribute to the increase of this percentage by being part of the EPS, developing awareness campaigns and establishing voluntary collection points in all factories[59]. The process used in Brazil is primary recycling, which is detailed below: • Containers are collected through a selective collection or by collectors and sent to the recycling plant. • The material passes through the recycling machine, the gas is removed from its composition, and the polystyrene is compacted into bales or transformed into billets (shaped like a loaf of bread). • The compacted material undergoes a second recycling process. The polystyrene is crushed, melted, granulated, and reused as raw material to manufacture new products.
Argentina	**Mechanical recycling,** The recovered EPS is compacted and baled. The bales are transported to the plastic recycling industry, which performs the recycling process to transform them into new consumer products. Mechanical recycling consists of an extrusion-granulation process. It goes through a smelter, brought to a solid state with water, and then pelletized and distributed as raw material. **Thermal recovery** This process consists of the recovery of energy from combustion, uses waste as fuel and takes advantage of the great calorific value of plastics to generate electricity and heat through combustion with clean technology. **Chemical recycling** This converts plastic waste into other hydrocarbon derivates. The chemical processes used in the Argentine industry are pyrolysis, from which products like fuel, oils, and gases are obtained; the depolymerization of which styrene is obtained to produce polystyrene again and dissolution allows obtaining polystyrene suitable for creating new products.
Chile	**Mechanical recycling** EPS, modified into final products, like blocks or pellets **Chemical Recycling** Manufacture of glue or varnish from EPS, a product obtained by mixing EPS with acetone. EPS dissolves and, depending on the amount, can become glue or varnish for coating. Another of the products obtained through recycling campaigns is paint used for exteriors. The paint obtained is usually used for signage on asphalt or exterior coatings. For this, a machine that converts the sheets of EPs into liquid expanded polystyrene is used. The plumavit with a series of additives is processed to obtain its liquid form, and then it is transferred to drums in which color and texture are added.

(2) PP recycling technology

[Table 3-16] PP Recycling Technologies by the countries in Latin America

Mexico	In Mexico, a recycling plant has been proposed and worked on. It produces “infinite” polypropylene that can be used for any required field. It consists of a physical process of separation and selection, after which it is subjected to purification, which removes all color, inks, organics, and contaminants that would be problematic for certification in food-grade applications. This process is compelled by generating property modifying additives, which allow the properties of recycled PP to be adjusted to the profile of properties required by different applications[60].

59 *Knauf Isopor®: Comprometimento com um Brasil sustentável - Knauf Isopor®*. (n.d.). | https://www.knauf-isopor.com.br/corporativo/sustentabilidade/ (accessed March 16, 2022)

60 *PureCycle, un PP infinitamente reciclable.* (n.d.). | https://www.plastico.com/temas/PureCycle,-un-PP-infinitamente-reciclable+136050 (accessed March 14, 2022)

Argentina	One of the technologies implemented proposes recycling plastic waste to produce construction elements. It consists of the manufacture of bricks, blocks for walls, plates, and roof blocks but replacing stone aggregates with recycled plastics. The plastic particles are placed together with Portland cement, additives, water, and in some cases, coarse sand in a concrete mixer, where a mixture is made until a uniform consistency is achieved. This mixture is then poured into a machine molding bricks or a block molding machine, depending on the type of element construction in question. They are mechanically compacted[61].

3.2 Ecuador

In Ecuador, 85% of the waste is collected from cities and 25% from rural areas. Of these, approximately 11% are plastics. Among the waste disposal methods, landfills are the most widely used, accounting for 70%, similar to the average in Latin America, whereas they account for 25% in Europe and 40% in Mexico. PET is the most recycled, and the processability of PE and PP vary. The scrap system in Ecuador has been used since the 1990s, and the need for technical improvements in waste screening and recycling has increased significantly. Plastic waste is landfilled or transferred to recycling facilities from various waste generation sites, including homes, stores, and factories. With the recognition of environmental problems caused by landfills, the Ecuadorian government has been increasing efforts to develop relevant technologies and raise the level of recycling. The post-consumer recycling process currently involves the following process:

Collection > Separation > (Sales) > or Grinding > Cleaning > (Sales)

The following chapters will explain the current recycling technologies used in Ecuador, focusing on EPS and PP.

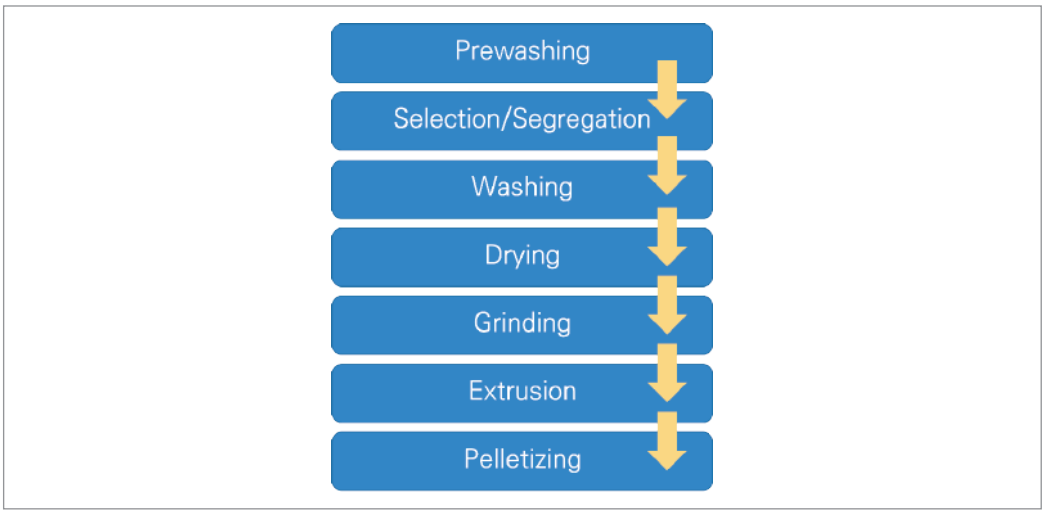
(1) EPS recycling technology

Specifically, EPS recycling is limited by the high cost of the machinery used in principle. Since the machinery used can only receive 100% EPS the process is extremely complex, from separation to reprocessing, Therefore, the selection and separation process is vital to avoid future damage to the machinery used. Additionally, the great economic and energy expense that recycling EPS represents is contemplated, in addition to the fact that too much water is consumed during the process. Finally, the physical treatment space for recycling must be extremely large because the EPS is 98% air. This occupies a large volume even though, by weight, it is insignificant.

61 Gaggino, R. (2009). *Tecnología innovativa para la construcción utilizando plásticos reciclados*. XII Jornadas Interescuelas/ Departamentos de Historia. Departamento de Historia, Facultad de Humanidades y Centro Regional Universitario Bariloche. Universidad Nacional del Comahue, San Carlos de Bariloche, 2009. https://www.aacademica.org/000-008/590

Due to the law on single-use plastics in Ecuador in 2019, Ecuadorian companies with EPS businesses stated that such strategies meet or exceed the law requirements. Plastic supported a project to develop a study case on recycling EPS. The company had already used the postindustrial EPS in its process several years ago. The laboratory test develops a procedure for post-consumer EPS as follows:

<Figure 3-24> Post-consumer EPS processing[62]

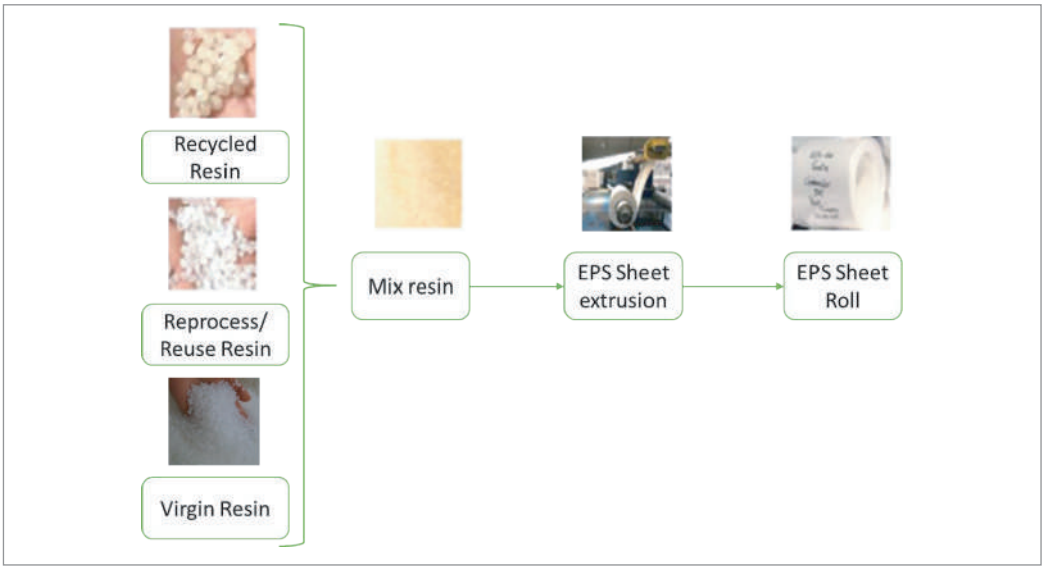


Source: J. Hidalgo-Crespo, et al., 2020

The manufacturing process details can be observed in the Introduction of the circular economy to EPS household waste: A case study from an Ecuadorian Plastics. The main purpose is to meet the law requirements. The company already uses 30% of reprocessed/reused scraps, so they incorporate another 30% from recycled post-consumer resin and the remaining 40% from virgin resin. An issue was contamination from the rest of the food, which may create some microorganisms. Fortunately, the extrusion involved a temperature of <200°C and approximately 120°C during reprocessing. These temperatures and the processing time of about 18 minutes were enough to remove and eliminate microorganisms, as in any other industrial sterilization process. Finally, a migration test was conducted to determine potential elements that could remain in the pelletized materials. All migration tests observed in the recycled virgin EPS were significantly lower than the requirement by Ecuadorian Technical standard INEN-EN 1186-1. The process samples were obtained in the industrial process, as observed in Figure 3-25.

62 J Hidalgo-Crespo, FX Jervis, CM Moreria, M. Soto, JL Amaya. Introduction of the circular economy to EPS household waste: A case study from an Ecuadorian Plastics

<Figure 3-25> Industrial process of Postconsumer



Source : J. Hidalgo-Crespo et al., 2020

Although there are no data about the waste number of EPS in Ecuador, one study revealed that the household composition of plastic waste in Ecuador is 5.3% and 10.3% for EPS and PP single-use, respectively Figure 38 illustrates plastic types of household waste in Guayaquil.

Other studies' Life cycle analysis(Circular economy of expanded polystyrene container production) included several scenarios in determining different environments, considering the differences in the valorization path, strongly concluding that recycling such plastic wastes could benefit the environment. The results were supported by Life cycle analysis software.[63, 64]

(2) PP rec nology

Polypropylene, for its part, does not show limitations in machinery since mechanical recycling is the most common and has a standard process, making it much easier and more feasible to recycle. However, this does not make it a 100% recyclable material because, according to studies, polypropylene would only withstand four recycling cycles before suffering thermal degradation due to its chemical structure. Therefore, to recycle polypropylene, it is necessary to synthesize it with virgin material. Additionally, due to

63 J. Hidalgo-Crepo, JL Amaya, M Soto, L Camanio-Gordillo, Domestic Plastic Waste in the city of Guayaquil: Generation Rate and Clasification. LACCEI International Multi-conference for engineering, Education and Technology. Buenos Aires Argentina July 21-23, 2021

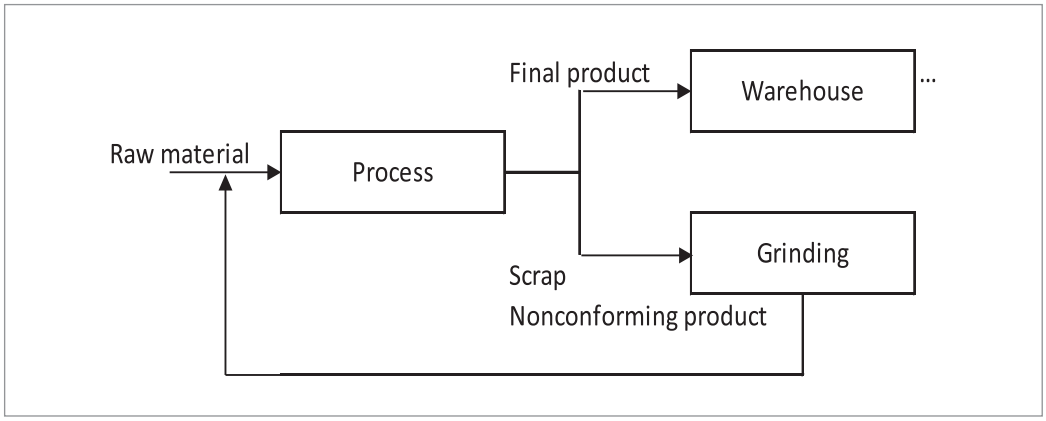
64 J Hidalgo-Crespo, CM Moreira, FX Jervis, M. Soto, JL Amaya and L. Banguera. Circular economy of expanded polyetyrare container production: Environmental benefits of household was recycling considering renewable energies Energy Reports 8 (2022) 306-311

the additives present, they can be harmful to health. Thus, recycled polypropylene is not approved for use in consumer items. Thus, this type of polypropylene is limited to using virgin material.

3.3 Plastic Companies' technologies in Ecuador

(1) EMPAQPLAST

<Figure 3-26> Flowchart of Empaqplast's plastic processing



Source: Personal communication. Empaqplast Interview (March 2022)

Empaqplast has been one of the main PE-PET-PP package producers for the cosmetic and food industries nationwide. With a monthly production range between 500 and 1000 tonnes, they have incorporated 90% of their pre-consumer waste into the production flow.

Empaqplast redesigned its waste management, increased resource productivity, and sought to reduce the consumption of natural resources in their production. Additionally, the company began promoting the recycling of plastic bottles among its employees, placing containers around the company for their collection. These bottles are then delivered to authorized waste managers for reinsertion into other production chains.

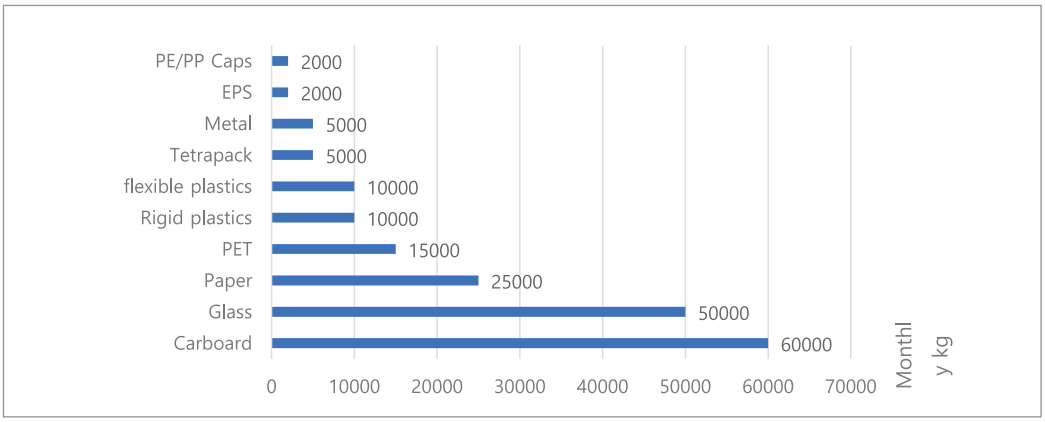
Their waste management also consists of the post-consumer production process. Post-consumer PE flexible packaging is collected and pelletized for either sale to other industries or manufacture 100% recycled bags for the following uses: garbage bags, sleeves for internal use, and sleeves for packaging products to be shipped to customers.

Regarding environmental responsibility, they have been involved in social projects to produce wood-plastic goods for school construction and planning different projects in biopolymers and agro-waste recovery.

(2)GIRA

GIRA works under a circular economy model aiming to achieve a positive impact on the world through the responsible management of resources and the creation of value in production chains, society, and the environment. To this end, it uses reduction, reuse, and recycling strategies to change the culture and traditional habits of waste management, with social and environmental impact.

<Figure 3-27> Monthly Porcessing amount for each Material



Source: Personal communication. GIRA Interview (March 2022)

GIRA has distributed 112 drop-off centers across the country, where they manage to recover around 150–160 tonnes monthly (cardboard, glass, paper, PET packaging, rigid/flexible plastics, tetra pack, tin, EPS, and plastic caps). GIRA serves as a collection and distribution center for PET bottles, glass, tin, cardboard, paper, and tetra pack (Collection → Selection → Compression → Selling). Rigid plastics and EPS have a grinding and washing pretreatment without undergoing a thermal transformation process (Collection → Selection → Grinding → Washing/Drying → Selling).

Flexible packaging undergoes an extrusion process to be incorporated once again into the productive chain (Collection → Selection → Grinding → Washing/Drying → Mechanical Recycling (Pellets) → Selling). GIRA collects and sorts post-consumer and post-industrial flexible plastic packaging, with a daily capacity of 6,000 kg. Additionally, GIRA processes and manages 100% of the secondary and tertiary plastic packaging from Corporación Favorita's supermarkets.

(3) FLEXIPLAST

Flexiplast started in Ecuador as a commercial bag manufacturer in 1994. Today, it is the

main supplier of PE, PP, and EPS goods to one of the largest grocery chains in the country. They apply a circular economy policy introducing a percentage of pre-consumer materials, when possible, into their products. In the PP and EPS plants where our interview was conducted, they use two types of recycling: 1) PP: grinding and incorporating around 20% in the production line and 2) EPS: grinding and extrusion transformation to pellets. The latter is used 100% for disposable goods and 40% for other production lines.

Their circular economy is extended to other processes in their organization like warehouse waste (stretch film and cardboard) and the cafeteria, where EPS tableware is washed and sent to the EPS recycling line for its extrusion and pelletizing.

Likewise, they offer consultancy for optimizing our customers' packaging, seeking sustainability through eliminating aluminum foils and metalized films, using recyclable materials, and reducing dimensions, thicknesses, and printed area. Additionally, since 2018 they have been working on developing plastic products with bio-based resins and bio-mass composites while waiting for a legal regulation that guarantees the correct regulation and disposal of this type of materials.

3.4. Limitations of plastic recycling in Ecuador

Ecuador does not present a potential market for recycled plastics, not even recycled materials. According to its material, be it metal, cardboard, and plastic (materials most commercialized today). The recycling problem starts at home since Ecuadorian families do not have a recycling culture. The few recycling activities are due to labor shortages that force people, known as informal recyclers, to work with garbage, trying to obtain valuable elements and sell them to recyclers later.

The above can be defined as the root of the recycling problem since it is a culture that should be promoted in homes, food businesses, or education systems. Additionally, the current laws do not have a framework to encourage home waste separation. The GAD can manage the waste without the obligation of waste separation. They are obligated to collect and dispose of the waste in the best way that GAD decides. There is a "gap" between society's needs and waste management from the GADs in Ecuador.

Conversely, many more inconveniences arise that limit the development of the recycling business in the country. Only high-size companies can afford efficient mechanical recycling technology. This lack of technology causes small companies not to meet current regulations regarding single-use material or circular economy laws. It should be a priority decision to

facilitate technology to the entire industry, especially in other significant populations than Guayaquil or Quito.

There is a lack of technical laboratories to support the plastics industry regarding recyclability testing or migration testing for plastic products sensitive to food markets. These issues are also related to the development of standard regulations for recycled products, including the traceability of recycled products.

Among the limitations that arise is the low educational level of environmental managers due to the lack of careers, such as environmental engineering or master's degrees in sustainable development and circular economy. Very few professionals manage to recycle appropriately, making the most of the resources and technologies. Thus, there are a few recycling or plastics industry educational programs.

Another limitation is the lack of associativity, which limits the power of negotiation. To promote the growth of recycling as an industry, large amounts of money are required as capital, and the association of several companies to cover all the processes, such as collection, treatment, and marketing, is necessary.

In the recycling industry, there are also ideas, such as the circular economy. After the COVID-19 pandemic and the health and economic crisis, there has been an interest in replacing the linear economy (commonly applied in Latin American countries) with a circular economy. A circular economy is an economic system that seeks to preserve natural resources and whose purpose is to simultaneously contribute to reducing the environmental impact of development, increasing the efficiency of the use of resources, and improving the well-being of all interested parties. The industry's ecological footprint in its production and post-production processes is also considered. Under this precedent in recent years, the Ecuadorian industry has experienced a non-technological eco-innovation concept. This is an innovation of the organizational and social nature that allows a transition toward a circularity model through research and innovation that drives significant changes in models of consumption, production, and the creation of sustainable products. Examples of this innovation include using recycled products as raw materials and reforming the production line to reduce waste and residues generated during the internal and external processes of the industry. Also, investment and research in projects aimed at generating and modifying products and services are aimed at fulfilling the pillars of sustainable development.

Despite this, it is not enough to introduce the circular economy to the industry since the influence of certain factors, such as the consumer and producer behavior model, must be

involved in developing the circular model. For the consumer, the willingness to use recycled products or to recycle on their own at home is contemplated. In contrast, for the producer, implementing incentives for consumers to use products that contribute to sustainable development is contemplated. In addition to considering the criteria of responsibility extended to the producer, which will determine new or improvements in the production processes, note that the last mentioned can be achieved considering individuality as negligible for developing the circular economy. For the industry and model, producers and consumers must be oriented toward the same goal. This situation is currently absent in the plastic recycling industry in Ecuador.

[Table 3-17] Main remarks on the use of recycled Plastics in Ecuador

There must be a plan to introduce some laws changes to encourage the system's limitations.
The lack of good quality recycled plastics to incorporate into their products. There are limited recycling technologies for the entire system, and only big-size companies can afford efficient recycling technologies. Companies should improve the process and recycling technology to improve the quality of their materials and products. A project in this line must be leaded by the Ministry of Productions
Limited educational programs to the industry or society relating to recycling and the importance of environmental awareness. The low recycling rate of plastic materials due to poor household separation influenced the low recycling culture and the inefficient recycle-oriented waste management for the GADS. A project ins this line must be led by the Ministry of Environment.
The lack of a waste management model to efficiently apply the recycled materials and waste disposal of solid waste. Some limitations of the laws support these issues. A project to advise the GADS is important since GADS manages waste collection and disposal in Ecuador.
The poor association of the ministry of environment and production as public entities is one of critical Ecuador's limitations in waste management. Waste management must approach all public systems, including ministry, GADS, industry, academics, and society.

04

CHAPTER

Korean case study

1. Policy and Law
2. Processing and Recycling
3. Korean Experience with Machinery and Recycling Models that Optimize the Process of Obtaining Raw Materials

Korean case study

1. Policy and Law

1.1 History and Process of the Development of Waste Policies and Laws in Korea

(1) Clean and hygiene (1961–1977)

The 「Waste Cleaning Act」 was enacted and promulgated in 1961, with the main content being the disposal of waste and excrement. The first full revision was made in 1973. At this time, the term waste was first used in the definition of filth. Additionally, the duty of cleaning was given to the public, and it was stipulated that the business operator should dispose of the filth independently. As environmental pollution intensified due to industrial development, the 「Pollution Prevention Act」 was enacted in 1963. However, there were no regulations on waste due to regulations on air pollution, river pollution, noise, and vibration.

(2) Environmental Conservation (1978–1986)

The 「Environmental conservation act」 was enacted by introducing regulations on industrial waste in the 「Pollution prevention act」 in 1977. The Environment Agency, which manages the overall environmental administration in an integrated manner, was launched. As a result, the government's response to environmental problems changed from a 'passive defensive concept' to an 'active conservation concept.' In the 「Environmental conservation act」, industrial waste disposal standards were separately set, and industrial wastes were differentiated from other wastes and started to be managed. A dual legal system was formed in which industrial wastes were managed under the 「Environmental conservation act」 and excrement and waste were managed under the 「Waste cleaning act」. As rural waste vinyl emerged as a socially active problem, the 「Plastic disposal business act」 was enacted in 1979.

However, household waste was still managed in accordance with the 「Waste cleaning act」 and industrial waste was managed in accordance with the 「Environmental conservation act」.

(3) Integrated waste management (1987-1992)

The 「Waste management act」 was enacted to reinforce the management of the nature and characteristics of waste by stipulating a single law on matters related to waste management, which had been divided into the 「Environmental conservation act」 and 「Waste cleaning act」. The 「Waste Management Act」 classifies wastes into household and business wastes, and management differs by the characteristics of wastes. This can be seen as the beginning of management according to the integrated waste management concept based on waste management reduction, recycling, intermediate disposal (incineration), and landfill.

(4) Waste minimization (1993–2003)

As waste increased rapidly in the 1990s, waste management policies shifted from safe disposal to recycling and reduction policies. The 「Waste control act」 focuses on disposal rather than recycling and reduction, and as the amount of waste generated increases rapidly and it becomes difficult to landfill, waste management with existing policies alone has become difficult. Accordingly, the 「Act on the promotion of saving and recycling of resources」 was implemented by separating the recycling regulations from the 「Waste control act」 to suppress waste generation and promoting recycling.

In addition to matters related to the responsibilities of the state, local governments, business operators, and citizens, this Act established a master plan for resource recycling. It introduced the “waste charge system” in addition to the deposit system introduced in the previous 「Waste Management Act」. In this Act, for the first time, a system to make recycling obligatory was introduced by designating businesses that generate a lot of recyclable waste, which later developed into a producer responsible recycling system, as recycling promotion industries and business operators. The concept and principle of resource circulation were introduced to change the direction of waste management policy from the previous safe disposal and simple recycling to suppression of generation and expansion of resources.

As waste continued to increase despite recycling, it was inevitable to install a waste disposal facility to deal with it. However, it was difficult to install due to opposition from residents, and it began to act as an obstacle to environmental conservation and national development. Accordingly, the 「Act on Promotion of Installation of Waste disposal Facilities

and assistance to adjacent areas act」was enacted in 1995 to resolve social conflicts, promote the installation of waste disposal facilities, and support the residents of areas who are directly affected. Additionally, when a large amount of construction waste was generated due to the expansion and maintenance of urban infrastructure, the「Construction waste recycling promotion act」was enacted to minimize the generation of construction waste and promote recycling.

(5) Introduction of the concept of resource recycling of waste (2007–present)

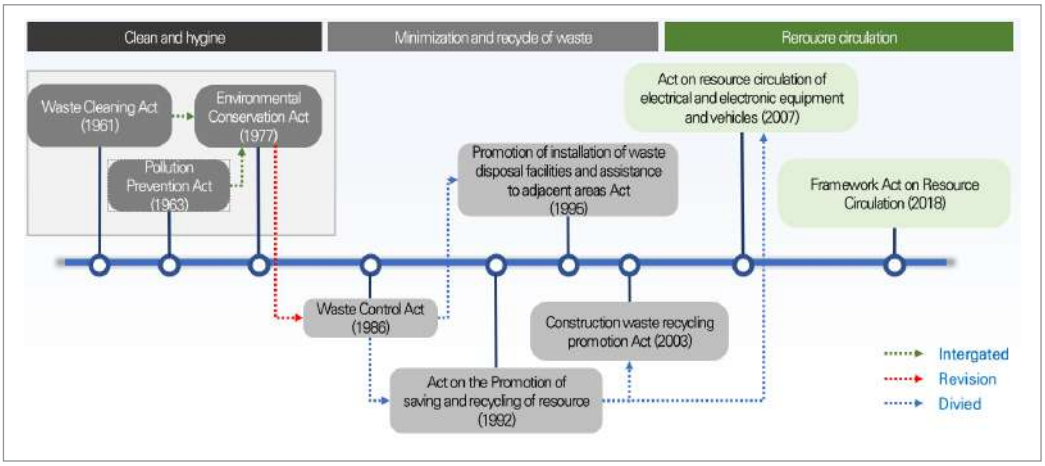
In the 2000s, the era of resource circulation was entered for efficient use of resources due to concerns about resource depletion. In 2007, a separate corporation, the「Act on resource circulation of electrical and electronic equipment and vehicles」was enacted for matters related to recycling of electrical and electronic products and automobiles. The main components are to limit the use of hazardous substances in the manufacturing stage, promote the recycling rate, improve the product using easily recyclable materials, etc.

In accordance with the law, the「Act on the Promotion of Saving and Recycling of Resources」, the regulations on Producer Responsibility for Recycling required manufacturers and importers of electrical and electronic products to collect and recycle more than a certain percentage of their shipment. In the 2000s, many systems related to recycling and energy recovery were implemented. Accordingly, in 2018, the「Framework Act on Resource Circulation」was enacted to reduce waste generation and maximize recycling and reuse to create a sustainable resource circulation society.

[Table 4-1] History of waste-related laws

~1980s	1990s–early 2000s	mid 2000s–present
Proper disposal	**Recycle and Reduction**	**Resource circulation**
• 「Waste Cleaning Act」 -abolition	• 「Act on the promotion of saving and recycling of resource」(1992) • 「Act on the transboundary movement of hazardous wastes and their disposal」(1994) • 「Act on Promotion of Installation of Waste disposal Facilities and assistance to adjacent areas 」(1995) • 「Construction waste recycling promotion act」(2003)	• 「Act on resource circulation of electrical and electronic equipment and vehicles」(2007) • 「Framework Act on Resource Circulation」(2016)
• 「Pollution Prevention Act」 - abolition • 「Environmental conservation Act」 - abolition • 「Waste control act」		

<Figure 4-1> History diagram of waste-related law in Korea



1.2 Current System of Waste-related Laws

In the current waste-related legal system, the recycling and disposal-related laws are separated and managed within the broad framework of waste disposal. It is classified into the higher laws, the 「Framework Act on Resource Circulation」 of Recycling and Disposal Laws. Recycling-related laws include the 「Act on the Promotion of Saving and Recycling of Resources」, the 「Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles」, the 「Act on Promotion of Recycling of Construction Wastes」, and the 「Act on promotion of Purchasing of Green products」. Regarding disposal, they include 「Waste Management Act」, 「Act on Promotion of Installation of Waste disposal Facilities and assistance to adjacent areas act」, and 「Act on the transboundary movement of hazardous wastes and their disposal」.

[Table 4-2] Waste-related law system in Korea

「Framework Act on Resource Circulation」

- (Purpose) establishment of resource circulation basis
- (System) the end-of-waste certification system, waste disposal charge system, the resource circulation performance management system

Recycling	Disposal
「Act on the promotion of saving and recycling of resources」	**「Waste control act」**
• (Purpose) Suppression of generation of packaging waste and disposable products, establishment, and promotion of recycling • (System) Waste Charging System, Voluntary Agreement System (VAS), Extended Producer Responsibility system(EPR), Separate discharge and labeling system, Restrictions on the use of disposable(single-use product) products, excessive packaging regulation system, packaging material structure evaluation system	• (Purpose) Establishment of a basis for proper waste disposal • (System) Volume-based Waste Fee System, recycling environmental evaluation, waste disposal licensing system
「Act on resource circulation of electrical and electronic equipment and vehicles」	**「Act on Promotion of Installation of Waste disposal Facilities and Support for Surrounding Areas, Etc.」**
• (Purpose) Restriction on the use of hazardous substances and promotion of resource circulation in the manufacturing of electrical and electronic products and automobiles • (System) Environmental guarantee system	• (Purpose) Consideration of affected area around disposal facility when installing waste disposal facility • (System) Obligation to install environmental impact assessment and waste disposal facilities
「Construction waste recycling promotion act」	**「Act on the transboundary movement of hazardous wastes and their disposal」**
• (Purpose) Establishment of infrastructure for proper disposal of construction waste and promotion of recycling • (System) Recycled aggregate quality standard, Obligatory use	• (Purpose) Prevention of environmental pollution by waste import/export management • (System) Waste import/export permit system
「Act on promotion of Purchasing of Green products」	
• (Purpose) Promotion of consumption of recycled products • (System) Good recycled product (GR) certification system	

(1) 「Framework Act on Resource Circulation」

a. Main Content

The 「Waste Control Act」 and 「Act on the promotion of saving and recycling of resources」 recognized the problem that it was impossible to realize a sustainable society that could overcome the resource and energy crisis and environmental problems. Accordingly, the 「Resource Cycle Basic Act」 was enacted to manage the use of resources more efficiently from production to distribution, consumption, and disposal of products, reduce the environmental load by minimizing waste generation, and promote the cyclical use of resources.

The 「Framework Act on Resource Circulation」 presents basic principles to promote the transition to a resource recycling society in a series of processes, including waste generation suppression, recycling use, or disposal. Article 4 has the character of a basic law by stipulating that when enacting or revising other laws related to resource circulation, the purpose and basic principles of this Act must be met.

b. Main system

The main systems of the 「Framework Act on Resource Circulation」 are the End-of-waste certification system, the resource circulation performance management system, and The Waste Disposal charge system.

[Table 4-3] Main systems of the 「Framework Act on Resource Circulation」

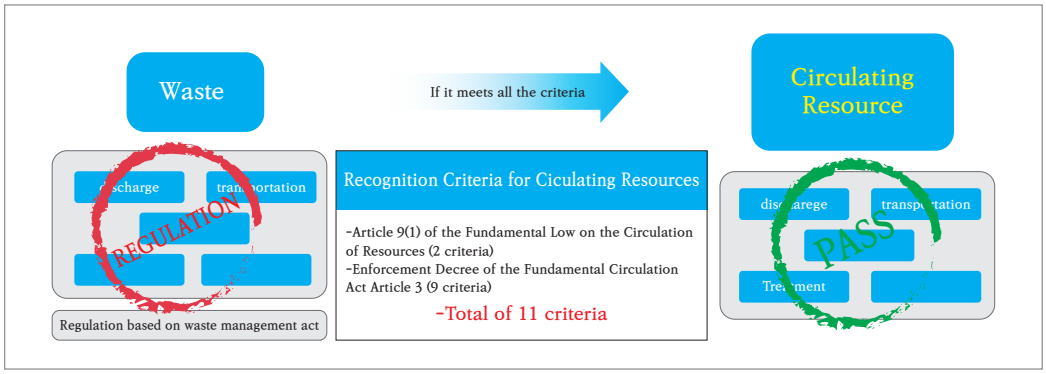
Category	Contents
End-of-Waste Certification System	A system that does not apply waste-related regulations by recognizing wastes generated at worksites as resources if they meet certain criteria, such as being not harmful to human health and the environment and economical.
Resource Circulation Performance Management System	A system that sets and manages resource recycling goals for each city/province and business that emits large amounts of waste
Waste Disposal Charge System	A system that encourages recycling as much as possible by imposing a fee on those responsible for disposal (local governments and workplace waste dischargers) who dispose of waste by incineration or landfilling.

① End-of-Waste Certification System

This system refers to the system in which, if waste fulfills all the circulating resource criteria, such as safety and economic feasibility to the human body and environment, it is accepted as a circulating resource and excluded from regulation for waste. The cost of collecting, transporting, and storing waste can be reduced to be used economically. Recycling

business operators are stipulated, and recycled resources are promoted by the certification system.

<Figure 4-2> Criteria for Recognition of Circular Resources



② **Resource Circulation Performance Management System**

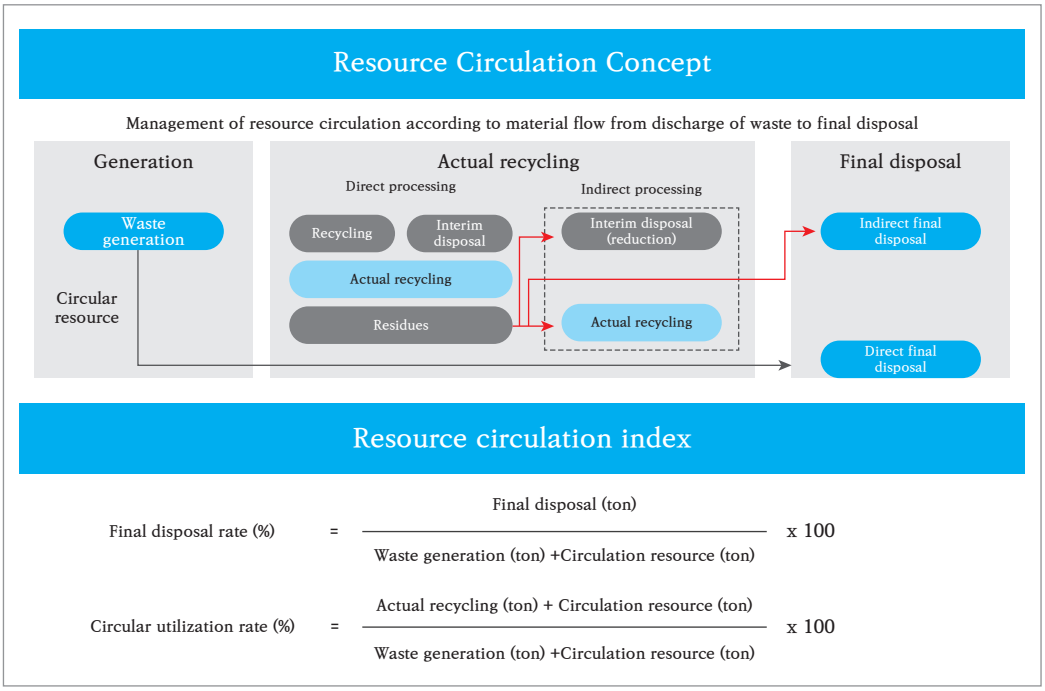
This system increases the circulating usage of resources and inhibits final disposal(Incineration and landfills), by managing the final disposal rate of direct and indirect landfills and the rate of the actual recycling, excluding the residues.

Performance management targets are local governments (provincials and cities) and workplaces that have produced more than 100 tons of designated waste or 1,000 tons or more of non-designated waste over the past three years.

Local governments voluntarily set and manage resource circulation goals in consideration of national resource circulation goals and conditions, and business operators strive to achieve the goals of resource circulation performance indicators (Circulation utilization rate, final disposal rate) granted by the government.

This system is operated by the Korea Environment Corporation. The Ministry of Environment receives reports on the data evaluated by the Korea Environment Corporation, evaluates them, and prioritizes financial and technical support and government awards for outstanding performers. If this is inadequate, achieving the goal is encouraged by technical diagnosis, guidance, and disclosure of the company name.

<Figure 4-3> Concept of actual recycling and final disposal

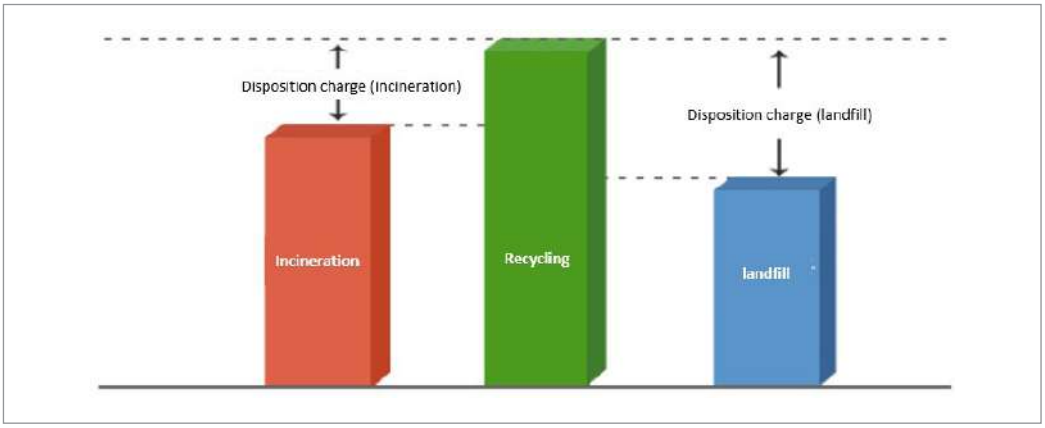


③ Waste Disposal Charge System

Despite implementing the waste-to-energy policy, dischargers prefer simple disposal (incineration and landfill) over waste recycling for economic reasons.

The waste disposal charge system refers to the system that imposes charges on subjects that dispose of waste by incineration or landfills to encourage waste recycling. Local governments and waste dischargers should pay the disposal charge.

<Figure 4-4> Concept of waste disposal charge system



[Table 4-4] Waste Disposal Charge Rate

Type		Rate	
		Landfill	Incineration
1. Household waste		kg per 1.4cent	kg per 0.9cent
2. Business waste	Non-combustible	kg per 0.9cent	-
	Combustible	kg per 2.3cent	kg per 0.9cent
3. Construction waste		kg per 2.7cent	kg per 0.9cent

(2)「Waste Control Act」

a. Main Content

The main contents of the「Waste Control Act」are the responsibilities of the state, local governments, and citizens and matters related to the discharge and disposal of waste (disposal standards, disposal of Household waste, obligations of the Business waste discharger, matters related to the disposal of Business waste, etc.), matters for the transparent disposal of designated wastes, and matters related to the waste disposal business. Additionally, specific installation and operation standards for waste disposal facilities are established. by this system, standardized treatment process is presented.

[Table 4-5] Classification and definition of waste and subject of disposal according to the「Waste control Act」

Category			Definition	Responsibility of disposal
Household waste	Municipal waste		Other wastes except for industrial wastes 1. Standard plastic waste bags 2. Food waste 3. Recyclable waste, including glass bottles 4. Bulky waste (furniture/appliances) 5. Business residential waste	Local government
Business waste	Municipal waste			
	Industrial waste		Business operations that install and operate discharge facilities like factories and those discharging over 300 kg daily	Discharger
	Construction waste		Over five tons of waste discharged from construction operation	
	Designated waste	Hazard waste	21 types, including waste oil, waste acids, and waste paint	
		Medical waste	waste feared to be contagious and discharged from medical, research, and inspection institutions	

b. Main system

The main systems of the「Waste Control Act」are the volume-based waste fee system, the recycling environment evaluation system, the waste disposal business license system, and the abandoned waste disposal performance guarantee system for neglected waste disposal.

[Table 4-6] Main systems of the「Waste Control Act」

Category	Contents
Volume-based waste fee system	A system to reduce waste and separate recyclables as much as possible by requiring the emitter to bear the cost as much as the amount of waste.
Waste disposal business license system	A system in which a person who intends to engage in the business of collecting, transporting, recycling, or disposing of waste must obtain permission from the local government having jurisdiction over the planned site of the facility or the local environment ministry
Abandoned waste disposal performance guarantee system	A system for preventing and appropriately disposing of neglected waste due to business closure, etc. when a waste disposal company that treats industrial waste stores waste within the workplace

① **Volume-Based Waste Fee System**

This system is designed to reduce waste on its own and separate recyclables as much as possible by requiring the discharger to bear a cost equal to the amount of waste thrown away.

The volume-based waste fee system is a product of that concern, and contains the Polluters Pay Principle (PPP), in which the person who causes environmental pollution bears the cost of environmental pollution removal. The necessity or theory of the volume-based waste system has already been raised since the 1980s. However, before the volume-rate garbage system was introduced in 1995, waste disposal fees were collected as a type of tax by levying them based on the area of the building or property tax. Below table, summarizes how fees for waste disposal were set up to the introduction of the volume-based waste volume system in 1995.

[Table 4-7] Garbage fee system when the volume-based system was introduced

Period	Waste type	Fee charge standards
`1980s	General waste (small amount)	Building area
	General waste (bulk)	Weight
	Business waste (small amount)	Building area

Period	Waste type	Fee charge standards
Early 1990`s	Household waste (small amount)	Building area/Property tax
	Business waste(bulk)	Weight
	Business waste(small amount)	Building area
~1994 (Before the introduction of the Volume-based fee system)	Household waste	Building area
	Business waste (small amount)	Building area
	Business waste (normal)	Volume
	Business waste (bulk)	Volume
	Construction waste	Volume
	home appliances Waste	Type, Volume
	Furniture Waste	Type, Volume
`1995~	General waste/food waste	Type/size/count/volume
	Bulk waste	Type/size/count
	Recyclable waste	Free

Source : Seoul Institute

For details necessary for implementation, the “Volume-based Waste Fee System Implementation Guideline (2015)” has been established and is being operated. The method for discharging waste according to the volume-based waste system is to dispose of household waste in standard bags produced by each local government and sold at stores (convenience stores, marts, etc.). If you do, you can collect it for free. With the implementation of the volume-based waste system, the amount of waste generated decreased while the amount of recyclable waste collected increased, which led to the rapid growth of the recycling industry.

<Figure 4-5> Effect of Volume based waste fee system

<Figure 4-6> Usage of Volume-based fee

[Table 4-8] Volume-based bag prices by local governments in Korea

(Unit: KRW)

Division	3L	5L	10L	20L	30L
Seoul	90	130	250	490	740
Busan	-	-	393	792	-
Daegu	100	150	290	560	-
Incheon	-	-	328	646	-
Gwangju	-	200	372	668	-
Daejeon	-	-	330	660	-
Ulsan	-	160	310	600	-
Sejong	-	-	270	540	-
Gyeonggi	100	148	287	567	840
Gangwon	-	170	225	407	-
Chung-buk	-	110	160	336	540
Chung-nam	-	140	199	384	-
Jeol-buk	-	-	209	385	-
Jeol-nam	70	89	182	334	300
Gyeong-buk	-	100	172	318	459
Gyeong-nam	150	157	262	502	-
Jeju	-	120	240	700	1,050

② **Waste Disposal Business License System**

This system is a system that permits only those who have an appropriate business plan and disposal facilities to improve the soundness of waste disposal and manage the disposal companies. The disposal business must present a business plan, facility and equipment specifications, disposal facility installation details and process diagram, the status of technological capability, and documentary evidence of the capacity of permitted storage facilities and the basis for calculation. Detailed information is presented in the "Waste disposal Business Permit Business Handling Guidelines (2015)."

By the waste disposal licensing system, it was possible to prevent overcrowding of inappropriate waste disposal facilities and secure soundness. This contributes to the smooth creation of statistics because it is possible to grasp the status of waste disposal in the private sector.

③ **Abandoned Waste Disposal Performance Guarantee System**

This system was introduced to prevent and appropriately dispose of neglected waste due to business closure, etc., when a waste disposal company that processes industrial waste in accordance with the「Waste Control Act」store waste in the workplace. A waste disposal company must obtain a related permit or report from an administrative agency, such as a local government, and pay a contribution to the waste disposal cooperative before starting the business or purchase an insurance guaranteeing waste disposal. Additionally, the payment of contribution and insurance must be maintained until the end of the processing business. Otherwise, administrative agencies, such as local governments, will take measures, including the cancelation of permission. By this, illegal disposal, such as re-consignment of waste, is prevented, and the relationship of responsibility for waste is clarified if left unattended.

(3)「Act on the Promotion of Saving and Recycling of Resources」

a. Main Content

The「Act on the Promotion of Saving and Recycling of Resources」aims to contribute to the preservation of the environment and the sound development of the national economy by restricting waste generation and facilitating recycling, etc., so that resources are used cyclically. Regulations are being prepared to suppress the generation of packaging waste. Additionally, regulations for resource conservation and waste suppression are being prepared, such as regulations to restrict the use of disposable products and to consider

resource circulation when the government implements development projects.

Additionally, to promote the separate collection and reuse of wastes, it is stipulated that recyclable wastes among wastes discharged from land or buildings must be recycled or stored separately by type, nature, and condition. Also, manufacturers of products and packaging materials requiring separate collection labeling to promote waste recycling must label their products and packaging materials for separate discharge in accordance with the guidelines set and announced by the Minister of Environment.

To promote the recycling of waste, a manufacturer or importer of a product or packaging that can facilitate recovery and recycling by the improvement of material structure or recovery system at the production and distribution stage or that generates a large amount of waste after use, is imposed with the duty of recycling by stipulating those wastes generated from imported or sold products and packaging materials must be recovered and recycled. The Minister of Environment must set the recycling duty rate considering recovery and recycling performance and conditions.

In the 「Act on the Promotion of Saving and Recycling of Resources」, the legal status of recycled materials is secured by defining recycled products of waste and stipulating standards. Additionally, in the Resource Recycling Act, for the effective use of recyclable resources, matters related to the installation and operation of public recycling infrastructure are prescribed by the Ordinance of the Ministry of Environment by the guidelines for the installation and operation of public recycling infrastructure.

b. Main system

In the 1990s, the waste charge and separate discharge labeling systems were introduced. In 2002, based on the polluter pays principle, a recycling obligation was imposed on producers of products and packaging materials that generate a lot of waste, while for lesser impact producers and consumers, the EPR system, voluntary agreement, and empty container deposit system was prepared to establish a recycling system that rationally shares responsibility for waste. Recently, a packaging material structure evaluation system has been introduced to improve the recyclability of packaging materials.

[Table 4-9] Main System of「Act On The Promotion Of Saving And Recycling Of Resources」

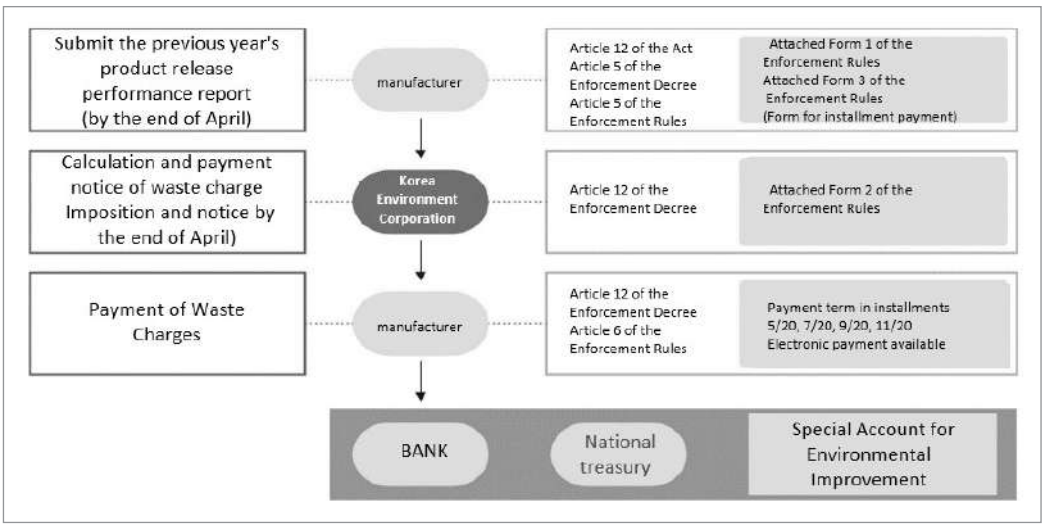
Category	Contents
Waste Charging System	A system that requires manufacturers or importers of products/materials/containers that contain hazardous substances or are difficult to recycle and may cause problems in waste management to bear the cost of waste disposal.
Voluntary Agreement System	A system for exempting waste charges when manufacturers and importers of plastic products subject to the waste charge and organizations that comply with the agreement sign a 'voluntary agreement on the recovery and recycling of plastic waste' with the Minister of Environment and implement it.
Extended Producer Responsibility Recycling System	A system in which product producers or producers of products using packaging materials are required to recycle a certain amount of waste from their products or packaging materials, and if this is not fulfilled, a recycling levy higher than the cost of recycling is imposed on the producer.
Separate discharge labeling system	A system that facilitates the separation of packaging materials subject to recycling obligations and increases the separation and collection rate of recyclable waste so that producers can smoothly fulfill their recycling obligations.
Empty container deposit system	A system that returns an empty container deposit to a person who returns the container after selling an amount separate from the factory price (empty container deposit) in the product price to facilitate the recovery and reuse of used containers.
Restriction of the use of disposable products	The use of disposable products (disposable cups, disposable plates, disposable containers, disposable wooden chopsticks and toothpicks, disposable spoons, forks and knives, disposable plastic tablecloths, etc.) in food service establishments is prohibited.
Packaging waste generation control system	A system to minimize the environmental and economic impact of recycling and disposal of wastes by suppressing waste generation in advance and preventing unnecessary waste of resources in advance
Packaging material structure evaluation system	A system to induce consideration of recyclability from the stage of product design and production by evaluating the material, structure, and recyclability of packaging materials

① Waste Charging System

This system that requires manufacturers or importers of products/materials/containers that contain hazardous substances, are difficult to recycle, and may cause problems in waste management to bear the cost of waste disposal. The rate and amount charged for each item are calculated, and the Korea Environment Corporation imposes it on the manufacturers and importers. However, if recycled materials are used for plastic products, the amount of shipments is reduced and exempted, and biodegradable resins are excluded from the scope. The waste levy is the revenue from the government's special account for environmental improvement, which includes purchasing, stockpiling, and recycling projects for recyclable resources, installation and support of waste disposal facilities, research and technology development for efficient waste recycling and reduction, and local autonomy. It is used to support the organization's waste collection and recycling costs and for other purposes prescribed by the Presidential Decree.

In accordance with the Polluter Pays Principle, as companies bear environmental costs for products with a high environmental load, companies reduce the amount of waste generated during the manufacturing and distribution stages and induce efficient collection and disposal of the generated waste to improve waste management. It reduces environmental costs and contributes to the use of recycled materials as well as the promotion of the use of biodegradable resins.

<Figure 4-7> Work procedure of waste charge system



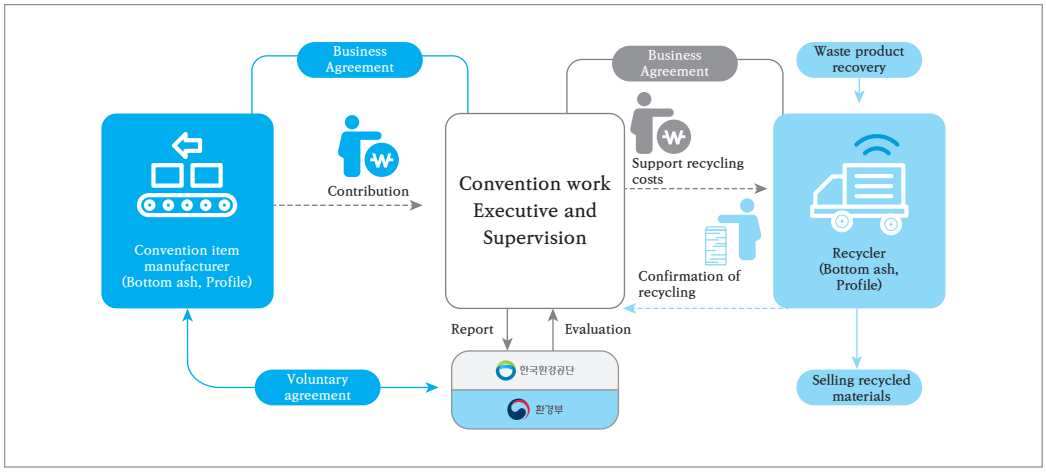
② **Voluntary Agreement System(VAS)**

This system in which manufacturers and importers of plastic products are subject to the waste charge (manufacturers fulfilling the agreement obligations), and organizations that fulfill the agreement obligations sign a recycling agreement with the Ministry of Environment, and if the agreement is implemented, the waste charge is exempted. It plays a role in the transitional stage before converting to the EPR system. 14 items are subject to voluntary agreements, and the Ministry of Environment and associations, as well as unions for each item are participating.

The qualification to apply for the agreement is only for those who operate a manufacturing business or a wholesaler/retailer or organization that sells manufactured or imported products to consumers as products using plastics as a material. Among them, producers or organizations that have a regional recovery system that can collect and recover items generated as waste, or have contracts with a recycling business operator equipped with it, are qualified.

Voluntary agreements are institutional regulatory means for resource conservation and circulation, contributing to changing the perception of business groups participating in such institutional operations and building the systems.

<Figure 4-8>Process of Voluntary Agreement System



[Table 4-10] Items subject to VAS

No.	Item	Management organization
1	Profile	KOVEC
2	Flooring	
3	Bumper molding for automotive AS	KARA
4	Rope	KOWRA
5	Safety net	
6	Nets (fishing nets, etc.)	
7	Pallet	KOPAL
8	Container	
9	PE pipe	KPPIC
10	Power/communication line	KOREACABLE
11	PVC pipe (including molded products)	KPPIC
12	Polystyrene foam for construction	EPSJOHAP
13	Daily necessities (20 items including kitchenware)	KPMR
14	Toys	

③ Extended Producer Responsibility (EPR) Recycling System

EPR encourages product producers to reduce, reuse, and recycle waste by inducing eco-friendly economic activities by product design, manufacturing, distribution, consumption, and disposal. This system promotes recycling and a 'resource circulation type economic and social system.' Items subject to the Producer Responsibility Recycling System are largely divided into products and packaging materials.

[Table 4-11] Items for EPR system

Category		Product·Package
EPR	packaging	Iron cans, aluminum cans, glass bottles, paper packs, PET bottles (colorless, colored, composite), foamed Plastic, polystyrene paper,
		PVC, container tray, composite material, and film sheet type single composite material
	Product	Lubricating oil, tire, mercury battery, silver oxide battery, lithium battery, nickel/cadmium battery, manganese battery, alkali/manganese battery,
		Nickel hydride battery, fluorescent lamp, float for aquaculture, film for packing silage, gimbal Jang made of Plastic

The overall responsibility for collecting and putting recycled waste into the recycling process rests with the government. The consumer ultimately bears the cost of recovery and recycling borne by the producer and plays a role in allowing waste to be easily collected by a separate discharge. Producers of the Producer Responsible Recycling System are broadly defined as distributors, packaging material manufacturers, product manufacturers, and raw material producers. However, since it is practically difficult to divide producers' responsibilities uniformly, only end-product producers and importers are charged a share.

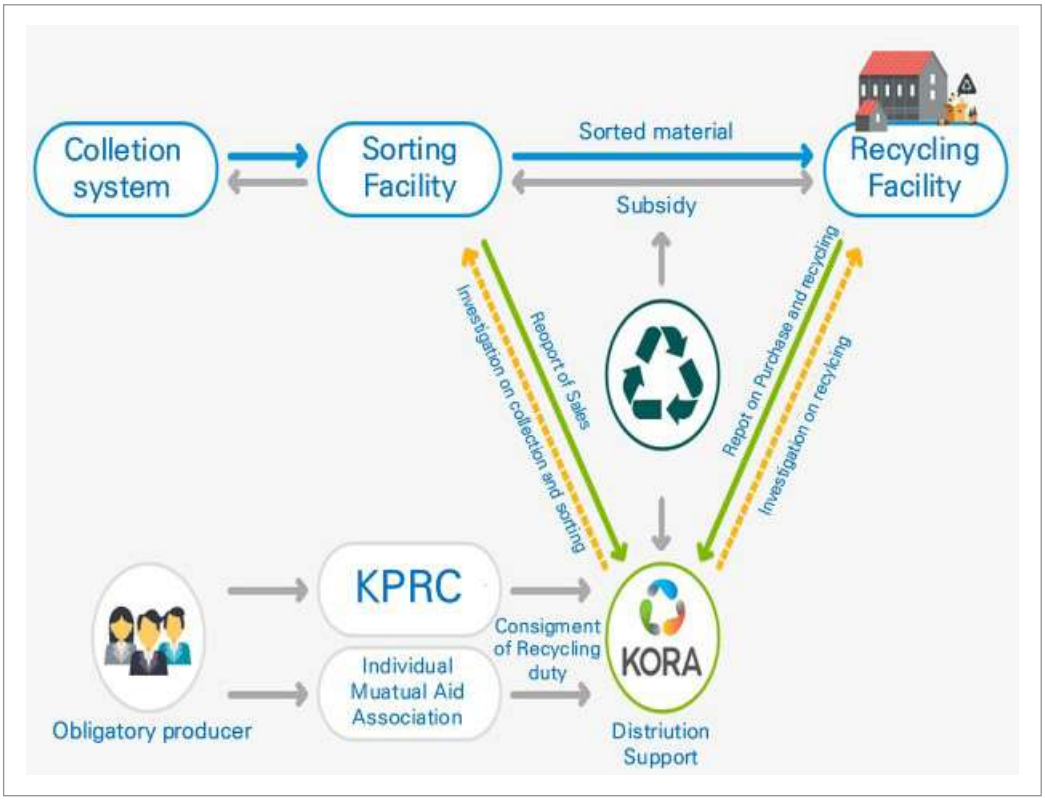
The amount of recycling obligation is calculated and announced annually by the Minister of Environment, and the recycling levy is differentiated according to the recycling non-compliance rate. When the Minister of Environment calculates and announces the recycling duty rate subject to EPR, it is calculated by comprehensively considering the recycling conditions (recycling performance, separate collection, and shipment) of obligatory producers. Since 2021, by evaluating the recyclability of packaging materials, additional premiums are imposed on packaging materials with materials and structures that are difficult to recycle, promoting material structure improvement.

Due to the implementation of the Producer Responsible Recycling System, the recycling performance is continuously increasing yearly, and the number of producers obligated to recycle according to the continuous expansion of target items has also increased, showing a positive ripple effect by the recycling industry.

[Table 4-12] Obligatory producer of EPR

Material	Shipment/Import	Sales/Income
Paper packs, metal cans, synthetic resin (plastic) materials (excluding foamed resin)	Annual output of four tons (imported one ton) or more in the previous year	in the previous year Annual sales of 1 billion won/Annual Income of 300 million won or more
Foaming resin (Including PSP)	Annual output of the previous year was 0.8 tons (import volume 0.3 tons) or more	

<Figure 4-9> Scheme of Extended Producer Responsibility system



[Table 4-13] Roles by stakeholders

stakeholder	Roles
Consumer	- separate discharge of recyclables
Recycling Obligation Producer	- Fulfillment of collection and recycling obligations
Recycling cooperative	- Contribution management for the joint fulfillment of recycling obligations
local government	- separation of collection work (penalties imposed on violators of the system)
Korea Environment Corporation	- Receipt and approval of the production volume by producer and the recovery/ recycling obligation fulfillment plan

stakeholder	Roles
Korea Environment Corporation	- Receipt of performance report on the fulfillment of collection and recycling obligations and confirmation of performance
	- Matters related to the implementation of the system, such as the imposition of a recycling levy
	- The recycling site confirmation and investigation
Ministry of Environment	- Overall system operation such as enactment and revision of laws
	- Announcement of calculation of recycling duty rate by item every year
	- Approval of establishment of Recycling Business cooperative and support and management of local governments and Korea Environment Corporation
	- Mediation and resolution of conflicts between stakeholders

[Table 4-14] Recycling duty rate and contribution

Category Total			Recycling duty rate(%)	Contribution (cent/kg)			
				Total	Recovery	Recycle	Operation cost(KPRC, KORA)
Can	Iron		0.843	(KPRC, KORA)		6.7	0.6
	Aluminum		0.807	11.4		10.3	1.1
Glass bottle			0.717	3.1		2.8	0.2
Carton	Paper		0.268	20.1	15.3		4.8
	Aseptic			24.5	15.3	5.1	1.6
PET-bottle	Colorless		0.800	12.2	2.1	9.3	0.9
	Colored		0.851	20.3	2.8	16.0	1.6
	Composite		0.851	31.0	3.3	25.3	2.4
Foamed Resin	Electronic product		0.844	5.7		5.2	0.5
	Agricultural			6.5		6.0	0.5
	Etc. (EPP, EPE)			21.8		20.1	1.7
PSP			0.523	25.5		23.5	2.0
PVC			0.385	78.1		72.0	6.1
Other Resin	Container or tray	PET	0.863	18.3	8.5	8.4	1.4
		Other (PE, PP, PS)		8.6	1.8	6.1	0.7
	Composite or Film, sheet		0.859	29.3	11.9	15.0	2.3
Film (PE, PP,)			0.859	29.3	11.9	15.0	2.3

The recycling contribution was calculated based on field survey data at university research institutes.

First, a standard process for waste recovery and recycling was selected by an on-site survey. Next, the cost of installing and operating machinery for the standard process that the appropriate investment model, which is the case when the social standard labor costs and appropriate facility investment were made, was calculated. It was calculated using the purchase cost of recycled waste and the sale cost of recycled materials.

- Recovery(collection and transport, sorting) subsidy (Won/kg) = Cost of selling recovered waste – Cost of recovery – Cost of purchasing waste

- Recycle subsidy (Won/kg) = Cost of selling recycle material – Cost of recycling – Cost of purchasing recovered waste

④ **Separate Discharge Labeling System**

The separate discharge has been partially introduced since the early 1980s. However, there were considerable difficulties in the implementation process, such as a lack of infrastructure to recycle the separated waste, unclear criteria for separate discharge, and friction with waste collectors.

Then, in 1991, when the separate discharge became obligatory, a fine of ≤1 million won was imposed on those who violated it.

In 2002, the “Guidelines on the Separate discharge Labeling System” was enacted, contributing to the proper separation of discharge of people.

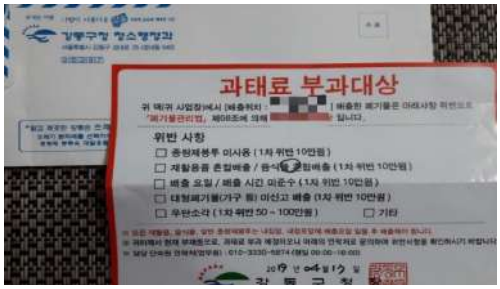
[Table 4-15] Packaging and Product to separate discharge labeling

Type of packaging(A)	Type of product (B)
- Cartons - Metal cans - Glass bottles (excluding products with an empty container deposit) - Plastic packaging material	- Food and beverages - Agriculture, fisheries, and livestock products - Detergents - Shampoo and conditioner for cosmetics and pets - Medicines and quasi-drugs - Butane gas products - Insecticide/disinfectant - Clothing - Paper products for hygiene - Rubber glove - Antifreeze, brake fluid, and lubricating oil (limited to plastic packaging materials) - Products other than the above (limited to Plastic packaging materials)
- Plastic film/sheet type packaging material and foaming Plastic cushioning material	- Electrical equipment and personal computers (including monitors and keyboards)
- Plastic disposable bags and shopping bags (excluding volume-based waste bags)	-

Recently, a recycling system has been implemented for each day of the week. For convenience, when using recyclables and waste disposal sites, we are distributing and operating the “Proper Separation of Recyclables and Disposal Dictionary” application that allows you to check various information on the discharge system for each day of the week by a smartphone.

The figure below presents the efforts that have been made to establish a separate discharge system in Korea in order.

[Table 4-16] Efforts to promote various separate discharges in Korea

<table>
<tr><td>  </td><td> 
</td></tr>
<tr><td>(1) Suggestion of the need for separate discharge by environmental organizations</td><td>(2) Obligatory separate discharge and imposition of fines</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>(3) Implementation of recycling-related systems</td><td>(4) Introduction of separate discharge labeling</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">(5) Establishment of separate discharge system for each residential area</td></tr>
<tr><td>Introduced separate discharge of houses (Door-to-door)</td><td>Introduction of separate discharge infrastructure centered on apartment (Station)</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>(6) Guidelines for separate disposal of recyclables</td><td>((7) Separate discharge promotion material</td></tr>
</table>

(8) Education for separate discharge

(9) Broadcasting a documentary related to the separate discharge

(10) Report on the problem of separate discharge by the news

(11) Separate discharge guidance and monitoring

(12) Discharge by day of the week and transparent PET bottles and vinyl

(13) Separate discharge application
(Separate discharge in my hand)

(14) Change in separate discharge method of houses
(door-to-door → station)

(15) Paid purchase of recyclable resources
(door-to-door → station)

⑤ **Empty Container and Disposable Cup Deposit System**

The empty container deposit system is a system in which an amount separate from the factory price (empty container deposit) is included in the product price to facilitate the recovery and reuse of used containers, and the deposit is returned to the person who returns the container after selling it. Items subject to the empty container deposit are the products using glass containers that can be used repeatedly. These products include fermented alcohol and distilled alcohol, beverages, and drinking water. Producers can decide whether to enforce the empty container deposit, and if they do not enforce the empty container deposit, they must fulfill their recycling obligations by the producer's responsibility recycling system. The procedure for fulfilling the recycling obligation of the empty container deposit system is the same as the workflow of the producer's responsibility recycling system, and if the recycling rate of products, including empty container deposits, is less than 80%, a recycling levy is imposed.

For instance, when ordering drinks at coffee shops, a certain amount of a resource recycling deposit is charged on disposable cups, and the deposit is returned to consumers when they return the cups. The deposit is determined by the Ordinance of the Ministry of Environment in consideration of the cup manufacturing costs and policy needs, and related research is currently in progress.

Consumers can get their deposit back, which is included in the product price, by returning the recyclable glass containers and disposable cups. Additionally, it greatly contributes to the environment and economy by reducing the cost of manufacturing new products and discharging air pollutants by increasing the return rate.

⑧ **Restrictions on the use of disposable products (single-use products)**

Food service businesses or group catering establishments restrict the use of the following disposable products. If a person who operates a facility or business category subject to the use of disposable products violates this provision and uses disposable products, a fine for negligence is imposed, which can be up to three million won.

[Table 4-17] Disposable(singe-use) products to use restrictions

Object	Exception
• Disposable cup (Plastic cups and metal foil cups, etc.)	-
• Disposable plate (Paper plate, plastic plate, metal foil plate, etc.)	-
• Disposable container (Paper containers, plastic containers, metal foil containers, etc.)	-
• Disposable wooden chopsticks	-
• Disposable Toothpicks	- Toothpicks made from starch - It can be used in a method that has a separate collection container and is provided only at the checkout counter or entrance
• Disposable spoon, fork, knife	-
• Disposable vinyl tablecloth	- Biodegradable products
• Disposable advertisements and promotional materials (Restriction of use, such as suppression of production and distribution)	-

⑥ Packaging Waste Generation Control System

The packaging waste generation control system is a system that minimizes the environmental and economic impacts of recycling and disposal of wastes by pre-inhibiting the waste generation and preventing unnecessary waste of resources in advance. In the case of packaging products to suppress excessive packaging, the space remaining in the box (packing space ratio) is limited to a certain ratio, and packaging (number of times of packaging) is regulated several times or conversion to a material that is easy to recycle is being implemented.

The packaging method regulation is a system that restricts the remaining space (packaging space ratio) in the packaging material when packaging a product to suppress excessive packaging and regulate cases of packaging multiple times (number of packaging). Packaging methods-regulated products are food, cosmetics, cleanser, goods, quasi-drugs, clothing, electronic products, and general products.

[Table 4-18] Standards for packaging methods by product type

Product			Standard	
			Packing space ratio	number of packaging
Unit product	food and beverage	processed food	under 15%	under 2
		beverage	under 10%	under 1
		alcoholic beverage	under 10%	under 2
		confectionery	under 20%	under 2
			under 35%	
		health supplements	under 15%	under 2
	cosmetics	Cosmetics (including fragrances)	under 10%	under 2
	Cleanser		under 10%	under 2
	goods	Toys and doll	under 35%	under 2
		stationery	under 30%	under 2
		stuff	under 30%	under 2
	quasi-drugs		under 20%	under 2
	cloth	Shirts and underwear	under 10%	under 1
Comprehensive product	Primary food, processed food, beverage, alcoholic beverage, confectionery, health supplements,		under 25%	under 2
	Cosmetics, Cleanser, household goods			

The packaging material regulation policy regulates the use of materials that are difficult to recycle. From September 1993, using EPS materials for toys, dolls, and all general products was prohibited. From January 2001, polyvinyl chloride (PVC) shrinks packaging materials were prohibited. The use of packaging materials bonding or coating polyvinyl chloride (PVC) was prohibited. Since January 2004, PVC packaging materials have been prohibited for packaging materials, such as eggs, quail eggs, fried foods, and hangers.

The packaging material structure evaluation system is a system that induces the consideration of recyclability from the product design and production stage by evaluating the material, structure, and recyclability of packaging materials. The applicable target is producers obligated to recycle packaging. After the obligatory producer has self-evaluated according to the evaluation criteria, K-eco confirms this and indicates the grade. According to the rating evaluation results, “recycling best,” “excellent recycling,” “normal recycling,” and “recycling difficulty” are indicated.

(4) 「Act on the transboundary movement of hazardous wastes and their disposal」

In 1989, the international community adopted the 「Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal」. This international community movement was caused by environmental problems and conflicts between countries as hazardous wastes were moved to developing countries due to strict waste regulations in advanced countries. Accordingly, to prevent environmental pollution on a global scale due to the illegal movement of hazardous wastes between countries and to support eco-friendly projects in developing countries, the international community has established a system for controlling and processing hazardous wastes. To accept this Basel Convention as a domestic law, Korea enacted the 「Act on the transboundary movement of hazardous wastes and their disposal」. To implement bilateral, multilateral, or regional agreements under the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Disposal of Hazardous Wastes, the Act regulates the export, import, and domestic transit of wastes. This aims to prevent environmental pollution caused by movement between countries and promote international cooperation.

(5) 「Act on Promotion of Installation of Waste disposal Facilities and Support for Surrounding Areas, Etc.」

Although the waste disposal facility is an essential social overhead capital facility in each region, it was difficult to install due to opposition from residents, which became an obstacle to environmental conservation and national development. The Act on Promotion of Installation of Waste disposal Facilities and Support for Surrounding Areas, etc., to facilitate the installation of waste disposal facilities by rationally resolving these obstacles, to facilitate the installation of such facilities, and to actively support the residents of neighboring areas directly affected by such facilities was enacted.

As the main content, it stipulates matters, such as site selection of waste disposal facilities to promote the installation of waste disposal facilities, support for residents of the facility site, support for surrounding areas affected, and financial support.

(6) 「Construction waste recycling promotion act」

Waste from construction sites, such as urban development, road and bridge construction, and apartment construction, is discharged in large quantities, and the recycling rate is low and environmental problems due to neglect have become serious due to the mixture of

soil, waste bricks, and waste wood. Accordingly, matters related to construction waste were separated from the 「Waste Control Act」 in 2003, and a single law related to construction waste was enacted.

Then, in 2009, the use of recycled aggregate and its products was made obligatory, and an electronic information processing program was introduced to input information regarding the handover and takeover of construction waste.

In 2013, the Act established regulations, such as the approval of temporary storage places for construction wastes so that they can be stored only in specified storage areas, requirements to be observed by users of recycled aggregates, and to promote recycling of recycled aggregates. Additionally, provisions to support research and development related to eco-friendly disposal and recycling of construction waste were amended. To promote the use and recycling of recycled aggregate, legislative efforts were made for resource recycling of construction waste, such as amending the quality standards for recycled aggregate and the obligation to use recycled aggregate.

The Construction Waste Recycling Promotion Act requires that construction waste be separated and discharged as much as possible by the business disposal guidelines for the disposal of construction waste, etc.

[Table 4-19] Separate discharge and disposal method of construction waste

Category			Disposal method
Combustible	Waste wood		• When recycling is possible—Consign to a recycling company that produces wood chips and sawdust • Things that cannot be recycled because they are contaminated with preservatives, oil, or stained with paint are incinerated.
	Waste plastic Waste fibers Waste wallpaper		• When recycling is possible—Consign to an intermediate recycling business or recycling business • When recycling is impossible - Consign to a company that has obtained an intermediate disposal business (specialized incineration)
Non-Combustible	Construction waste materials	Waste concrete Waste Ascon Waste brick Closed block construction waste	• Consign to a construction waste intermediate disposal company (recycled aggregate production) • Landfill what can't be recycled • Waste asphalt can be produced as recycled aggregate for asphalt concrete or recycled by companies that can produce recycled asphalt (construction waste intermediate processing business equipped with recycled asphalt concrete production facilities)
Combustible and non-combustible mixture		Waste boards	• Recycle what can be recycled, incinerate what can be incinerated among non-recyclable things, and landfill what cannot be incinerated

Due to goods production and consumption, there were concerns about resource depletion and a sharp increase in environmental pollution. To promote the production and consumption of eco-friendly products that can save resources and reduce environmental pollution compared with other products, public institutions are obligated to purchase eco-friendly products and support the purchase of eco-friendly products.

The 「Act on Promotion of Purchasing of Green Products」 aims to promote the purchase of green products, thereby preventing the waste of resources and environmental pollution, contributing to the reduction of greenhouse gases, and contributing to the sustainable development of the national economy. To this end, to promote the purchase of eco-friendly products by public institutions, the Minister of Environment has established a basic plan and purchasing guidelines and made the purchase of eco-friendly products obligatory. In cases where it is difficult to purchase products, exceptions are recognized. For public institutions to take responsibility for purchasing eco-friendly products on their own, they must publish their purchase implementation plans for eco-friendly products.

<Figure 4-10> System of green product purchase system

There is a green certification system as the main system of the law. The green certification system consists of green technology certification and green business certification. In the green technology certification, the government considers the technological feasibility and marketability for technologies that minimize greenhouse gas and pollutant discharges by saving and efficiently using energy and resources.

Green products minimize the environmental impact at the use stage and social costs by reducing environmental restoration costs. From the consumers' perspective, purchasing green products contributes to social and environmental benefits.

It also contributes to the national economy by inducing companies to develop and produce green products, by expanding the purchase of green products as an act that brings economic benefits, and by contributing to the strengthening of the environmental competitiveness of products. The types of certifications for green-certified products are as follows.

[Table 4-20] Type of Certifications

Category	Eco-label certified product	Low-carbon certified product	Good recycled product
Label			
Purpose	Product certification with excellent environmental quality by the entire process (Satisfied with KS quality or higher)	Products with reduced greenhouse gas discharges among products certified for environmental labeling	By recycling waste resources Certification of high-quality products among manufactured products
Target items	165 product groups, including office equipment, home appliances, and household items	All products except medical equipment, pharmaceuticals, primary agricultural, livestock, and forestry products	11 fields, including waste paper, waste rubber, waste plastic, and waste wood

(8) 「Act on resource circulation of electrical and electronic equipment and vehicles」

To promote the recycling of electrical and electronic products and automobiles, it was enacted to actively respond to the internationally tightened environmental regulations by suppressing the use of hazardous substances, manufacturing for easy recycling, and

establishing a resource circulation system that uses resources efficiently.

As mentioned above, the Act on Resource Circulation of Electric/Electronic Products and Vehicles is a law of the environmental guaranteed system. The use of hazardous substances is suppressed to promote the recycling of electric/electronic products and automobiles. This project aims to contribute to the preservation of the environment and the sound development of the national economy by establishing a resource circulation system that uses resources efficiently by allowing the waste to be recycled appropriately.

Accordingly, the state and local governments are responsible for preparing resource recycling policies to promote the recycling of electrical and electronic products and automobiles. Responsibilities, such as improving the structure to make it easier to recycle, or importing products that are easy to recycle, are given. Additionally, to restrict the use of hazardous substances, regulations, such as the subject and content standards of hazardous substances, are established, and regulations on recycling are prepared.

The main system includes the environmental guaranteed system. To promote the recycling of electrical and electronic products and automobiles, the entire process from design and production to disposal is covered, such as suppressing the use of hazardous substances, enhancing the ease of recycling, and appropriately recycling the waste.

2. Processing and recycling

2.1 Waste disposal process

In Korea, disposal responsibilities vary according to the source of waste in the 「Waste Control Act」, and they are broadly classified into MSW (municipal solid waste) and business waste. MSW is collected and transported by LGs (local governments) directly or by agencies and treated at public waste disposal facilities. Volume-based waste bags are mainly processed by incineration and landfill, and recyclable resources and food waste are separated, discharged, collected, and transported for recycling.

In accordance with Article 18 of the 「Waste Control Act」, the emitter directly handles (self-disposal) or, if direct disposal is impossible, contracts with a licensed disposal company to entrust collection, transportation, and disposal. However, LG can dispose of business waste generated at more than 300 kg daily in shopping malls, offices, schools, etc., that does not contain hazardous or difficult-to-disposal has properties similar to MSW.

Separate discharge of MSW is obligatory, and the separate discharge method differs depending on the waste. It is separated into VBW (volume-based waste), FW (food waste), and RW (Recyclable waste). Fluorescent lamps and batteries are separately discharged as hazardous waste.

VBWs are brought in by a vehicle and incinerated. If there is no incinerator in the area, vehicles are switched to large vehicles, and they are buried or incinerated. Following the landfill zero policy, combustible and non-combustible discharges have been induced separately.

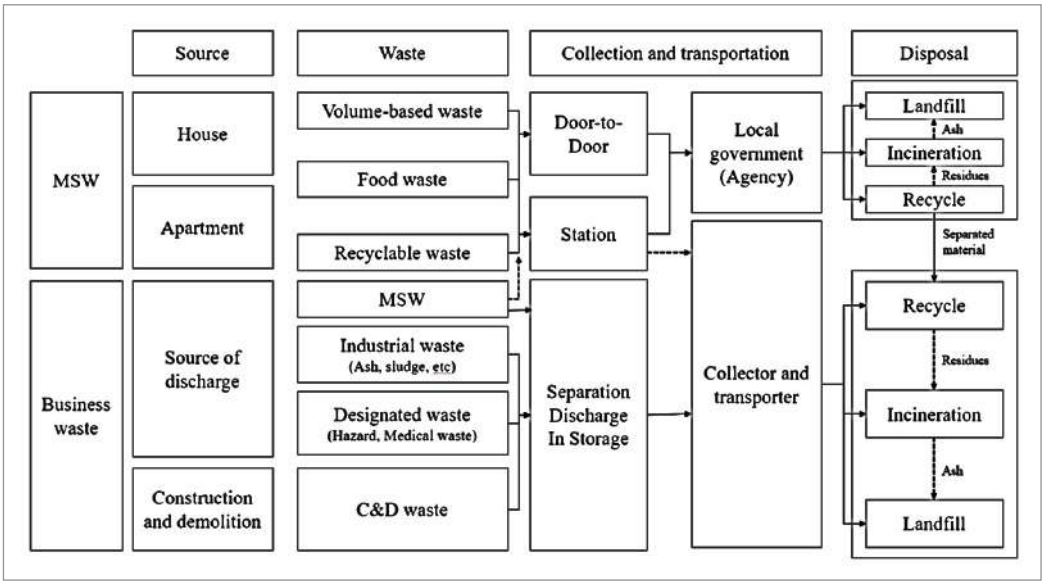
FW is treated at recycling facilities (composting, feed, biogas, etc.). If there are no recycling facilities in the area, private recycling facilities are entrusted with the processing.

RW, the disposal system for houses and multi-family houses, differs. Houses are mixed and collected at the RW recovery facilities installed in the LG. Valuables are re-sold, and attached items are incinerated and landfilled. Since apartments are separately discharged by type at the discharge source, a private collection and transport company licensed by the LG collects and transports them by type, reselects them when necessary, and sells them to consumers as valuables.

Bulky wastes are reported to the LG according to the fee system set for each type and are collected by a specialized company while paying the disposal cost, dismantled and recycled, or incinerated.

In the「Waste Control Act」, business wastes are classified into MSW, industrial waste, construction wastes, and designated wastes (hazardous and medical waste). The management system differs depending on the type of waste, so the vehicles collected and transported, transport methods, and disposal facilities differ. The discharger is responsible for the disposal; but if the discharger does not have a waste disposal facility, collection and transportation, recycling, incineration, and landfill are entrusted to private facilities.

<Figure 4-11> Waste disposal process in Korea



2.2 Recycling system for recyclable waste

(1) Discharge

In Korea, MSW is divided into door-to-door and station (drop-off site) discharges as well as into mixed and separated discharges. Recyclable wastes are separated from papers, cartons, plastic containers, transparent PET bottles, vinyl, foamed plastic, glass bottles, metal cans and scrap iron, electronic waste products, and others (clothes and fabrics, waste batteries, waste cooking oil, waste fluorescent lamps, etc.).

Papers are classified into newspapers, booklets, notebooks, paper cups, and boxes. Books and notebooks are disposed of after removing the vinyl-coated covers and springs. Paper cups are disposed of as general waste if they are small or contaminated. Papers and other materials, such as tapes and waybill stickers, are removed from boxes and then folded and discharged to prevent foreign substances from mixing.

Cartons are divided into Aseptic carton and Gable top carton, and the contents must be emptied, foreign substances removed, and dried. Gable top carton and other materials, such as straws and plastics, are removed and are to be disposed of in a Gable top carton application collection box so that they are not mixed with general paper.

Plastic containers (PVC, PE, PP, PS, and colored PET) are to be discharged after removing foreign substances and other materials, such as attached trademarks and accessories, from

the body.

Transparent PET bottles should be discharged by pressing after removing foreign substances and labels. Vinyl is discharged by removing foreign substances, but they are placed in a bag, so they do not scatter. Vinyl is often discharged with foreign substances and is a major cause of a decrease in sorting rate due to its light size and is discharged separately.

EPSs are divided into EPS boxes and cushioning materials. EPS and other materials like foreign substances and attached trademarks are removed and discharged. When purchasing electronic products, such as TVs, packaging materials used as cushioning materials should be returned to the place of purchase as much as possible.

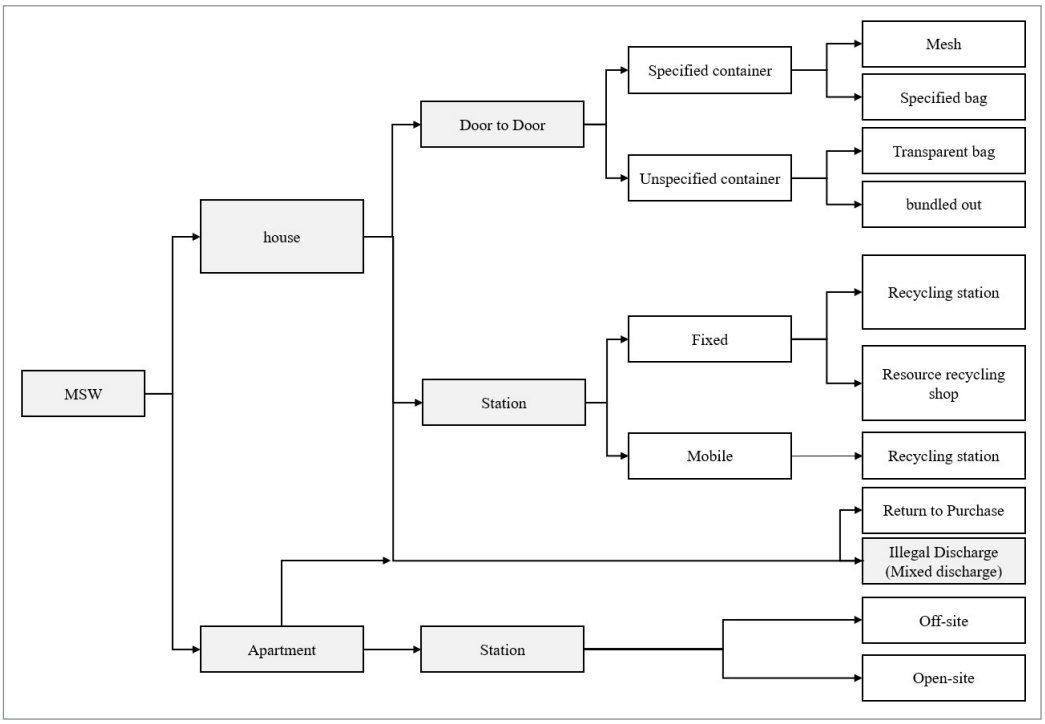
Glass bottles are divided into beverage and other bottles, and foreign substances are removed and discharged. Glass bottles subject to the deposit for empty containers, such as soju and beer, must be returned to retail stores, etc.

Metal cans are classified into scrap iron and non-ferrous metals (aluminum, etc.) depending on the material. For beverages, liquor cans, food cans, foreign substances and plastic lids, and other metal cans and materials must be removed before discharging.

The separate discharge system differs for each type of housing (house and apartment). There are various types of houses depending on the discharge point and the type of container. Appropriate types are selected and applied according to conditions like civil complaint management, topography and road conditions, and financial conditions. Most of them are placed in a transparent bag or bundled so that the contents of each item can be seen on a designated discharge day, but the method for discharging to the door has recently been applied.

Most of the apartments are based on the station discharge, and the permanent installation type and the installation type by day of the week are applied. Since the recycling bins are installed separately for each item and managed by apartment security guards, the condition of recycling is good, and there are fewer problems, such as illegal dumping, compared with other housing types. When discharging recyclable waste, the administrative regulations stipulate the discharge guidelines, such as minimizing pollution or removing substances that interfere with recycling.

<Figure 4-12> Discharge system of recyclable resources



Recycling stations are divided into a mobile station that repeats installation and dismantling in accordance with the collection time of recyclable waste, an urban living housing station installed for separate collection of recyclables in houses, and a clean house station for common areas of residential areas to collect recyclables.

Recently, an AI recycling station and a resource recycling shop have appeared, changing the separate discharge system by public-private cooperation. Recycling bins and resource recycling shops applied artificial intelligence (AI) and Internet of Things (IoT) technologies to collect and bring PET (colorless, colored, and plate) and plastics (PE, PP, PS, and others) to a certain point. Incentives obtained by returning recyclable resources are paid in the form of local currency that can be used in the region.

Apartment is obligatory to install a separate discharge site. There are two types of separate discharge sites: the closed type, which is built in the form of a building, and the open type, which utilizes a part of the parking lot, and most of the new apartment use the closed type.

<Figure 4-13> Types of door-to-door discharges

	
Designated container (mesh)	Designated container (specified bag)
	
Undesignated container (Transparent bag)	Undesignated container (bundled)

Figure 4-14 | Types of station discharge for house

	
Recycling station	Clean house
	
Urban living housing station (multi-family housing)	Urban living housing station(house)

Recycling station (mobile station)

AI recycling station

AI recycling station (Single Item)

Resource recycling shop

Figure 4-15 | Types of station discharge in Apartment

Off-site

Open-site

(2) Collection

Separately discharged recyclable wastes are collected by local governments and private collectors. Houses are mostly collected by local governments because they generate little waste, take a long time to collect, and are improperly separated. Conversely, apartments generate a lot of waste and are well separated, so they are mainly collected by the private sector.

Compressed vehicles and general vehicles were used for collection. However, compressed vehicles have recently caused damage to recyclable resources, so local governments stipulate that only general vehicles should be used to collect and transport recyclable waste.

Additionally, recyclables have been collected without any guidance so far, but to citizens' perception that recyclable resources are mixed and collected, an exclusive vehicle for each item is designated, and a notice board is attached to separate recyclable waste by implementing a daily discharge system. Also, private collectors (called junkman) collect recyclable waste in houses and commercial areas using trucks or rear cars.

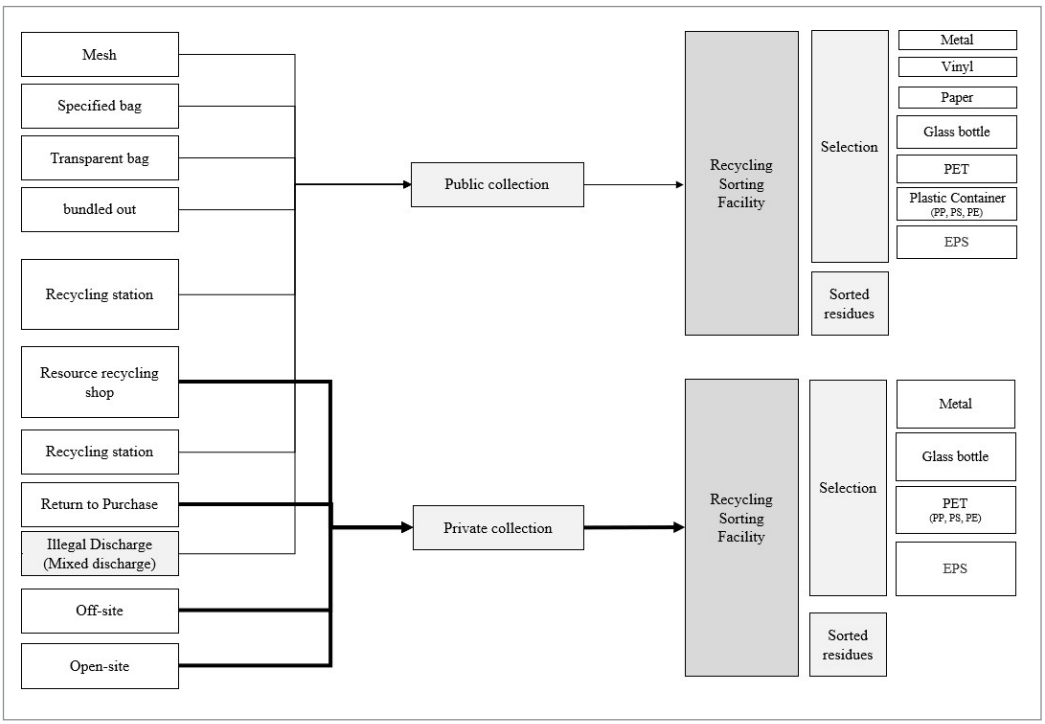
<Figure 4-16> Types of vehicles for collection of recyclable resources

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>General (house and mixed collection)</td><td>General vehicles (apartment and mixed collection)</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>General vehicles (Apartment and collection by item)</td><td>Compression vehicle</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">Junkman</td></tr>
</table>

(3) Recovery (collection and transport, sort)

The collected recyclable resources are transferred to a sorting facility or brought directly to a recycling company. Although sorting facilities differ, they are generally composed of the input process, the hand sorting process, the specific gravity sorting process, the magnetic sorting process, the automatic glass bottle sorting process, the automatic plastic sorting process, and the compression process. The input process is a process of introducing recyclable resources into the conveyor belt after breaking them. Recyclable resources that have been broken up are classified as large wastes by a hand sorting process and high- and low-specific gravity materials by a specific gravity ballistic sorter. Metals and glass bottles with high specific gravity are selected, and paper, plastics, and vinyl with low specific gravity are selected. In the magnetic sorting process, magnetic materials are selected among the recyclable resources moving on the magnetic sorting conveyor belt. In the automatic glass sorting process, they are classified by color. Low specific gravity materials are separated from waste vinyl and waste paper by hand sorting and then go by an automatic sorting process that separates them into PET, PE, PP, and PS by a near-infrared sorter. The manufactured EPS and PSP are produced as recycled materials in the form of ingots by a separate reduction facility in the sorting facility. The compressed sorted products and recycled materials are transferred into recycling companies and produced as new products.

<Figure 4-17> Collection, transport, and sorting system for recyclable waste



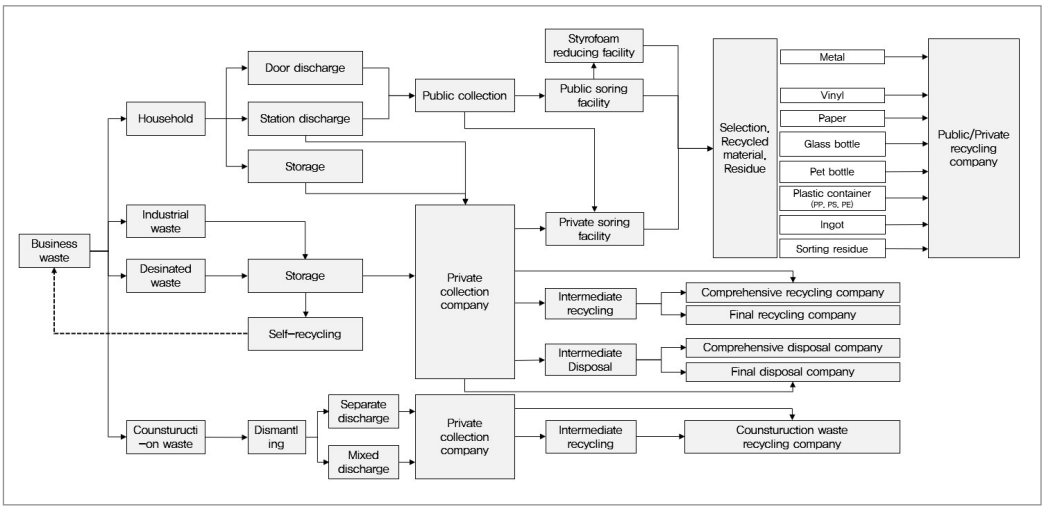
<Figure 4-18> Types of Recyclable watse Sorted Products

	
Metal scrap (cans)	Waste glass bottle
	
Waste paper	Waste plastics
	
Transparent PET	PE, PP, and PS
	
Waste vinyl	EPS/PSP

2.3 Business waste recycling system

Recyclable business waste resources are derived from household, industrial, and construction wastes. Designated waste is not treated as a recyclable resource due to its unique hazards. Industrial waste is managed similarly to domestic waste, but it can be seen that the concept of schools, food courts, department stores, and agricultural and fisheries markets, which are large sources of discharge, have been added. Discharge facility waste is waste generated by manufacturing a product using recyclable resources and is easy to recycle as it has a homogeneous appearance. However, in the case of the waste remaining after the disposal of household waste in a sorting facility, etc., it may be difficult to recycle due to its complex properties. Except for industrial waste, all wastes are treated by the private sector, and the discharge system is relatively uniform in appearance. In contrast, construction waste is difficult to recycle due to poor properties unless it is separated and dismantled. Recyclable resources among construction waste include used foamed plastic, plastic, scrap iron, and waste glass, which are recovered and recycled.

<Figure 4-19> Collection, transport, and sorting system for recyclable resources in business waste



<Figure 4-20> Types of recyclable resources among business wastes

	
Waste Plastic (PP and PE) scrap	PP pellet manufacturing by-product
	
Waste buoy	Waste EPS (waste packaging material)
	
Aluminum scrap	Waste glass bottle (defective bottle)
	
Sorting residues	Construction waste EPS

3. Korean experience with machinery and recycling models that optimize the process of obtaining raw materials

3.1 EPS Recycling Process

(1) Summary

In Korea, foamed plastics include EPS (Expanded Poly Styrene), PSP (Poly Styrene paper), EPP (Expanded Polypropylene), and EPE (Expanded Polypropylene Ethylene). EPS and PSP are mainly recycled, and they are recycled by a similar recovery and recycling system. In this study, all foamed plastics were expressed as EPS.

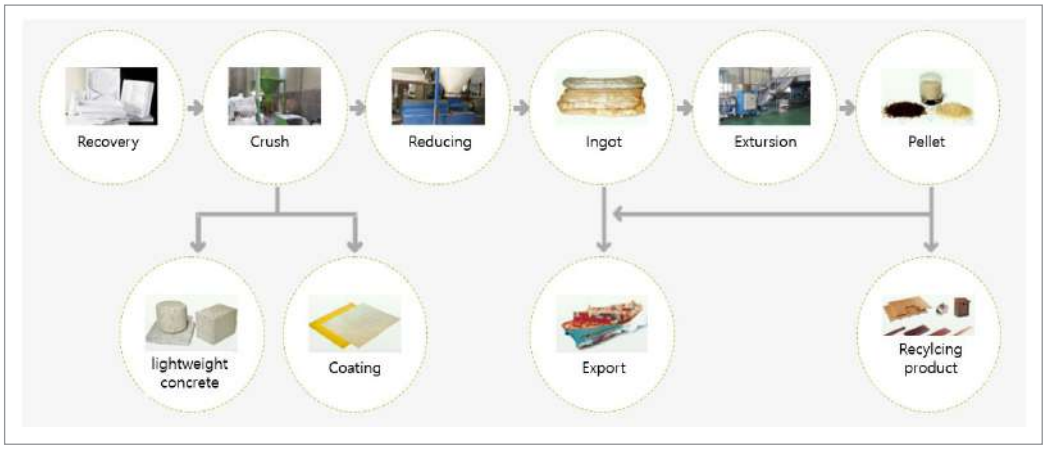
[Table 4-21] Overview of EPS and PSP

Category	EPS	PSP
Production Method	· Plastic (PS) manufacturer produces products by injecting foaming gas into styrene monomer (SM) · Products produced by an EPS molding company injects steam into EPS beads and foam them 50 times	· PS manufacturer produces styrene multimer (PS) · PS sheet manufacturer injects foaming agent into PS and foams it ten times to produce sheets and containers
Main Use	· Building insulation (sandwich panel, etc.) · Home appliances and parts cushioning and packaging materials · Packaging materials for agricultural and fishery products and food.	· Cup noodle container · Lunch container · Various food saucers · Fruit flat
Generation of Waste	· Home and restaurant · Electronic product distribution center · Home appliance and textile manufacturers · Agricultural and fishery products market and large distribution stores	· Home and general workplace · Agricultural and fishery products market and large distribution stores
Recycling and Recovery System	· Collected from local governments, home appliance agencies, home appliance manufacturers, and wholesale/retail markets and recycled on their own or consignment	
Recycling Method	· Production of ingots and pellets · After grinding, production of lightweight poles, fiber coatings, and refractory steel cladding materials	· Low-grade recycled materials are produced by mixing with EPS reducing machine

(2) Recycling Process of EPS

The figure below summarizes the recycling process of EPS. The recovered EPS is pulverized and used as a building material. It is produced as ingots by reduced volume disposal. Ingots are exported or transported to other recycling companies, where they are made into pellets and then produced into various recycled products. However, the method of manufacturing ingots has problems, such as physical properties and colors due to heating, so the package-to-package method is difficult.

<Figure 4-21> EPS Recycling Process in Korea



① **Discharge**

EPS has a large volume, so its collection is avoided. Therefore, it is discharged in a clean state without foreign substances, and if the size is small, it is collected and discharged in a transparent vinyl. Contaminated items cannot be recycled but may be incinerated or landfilled.

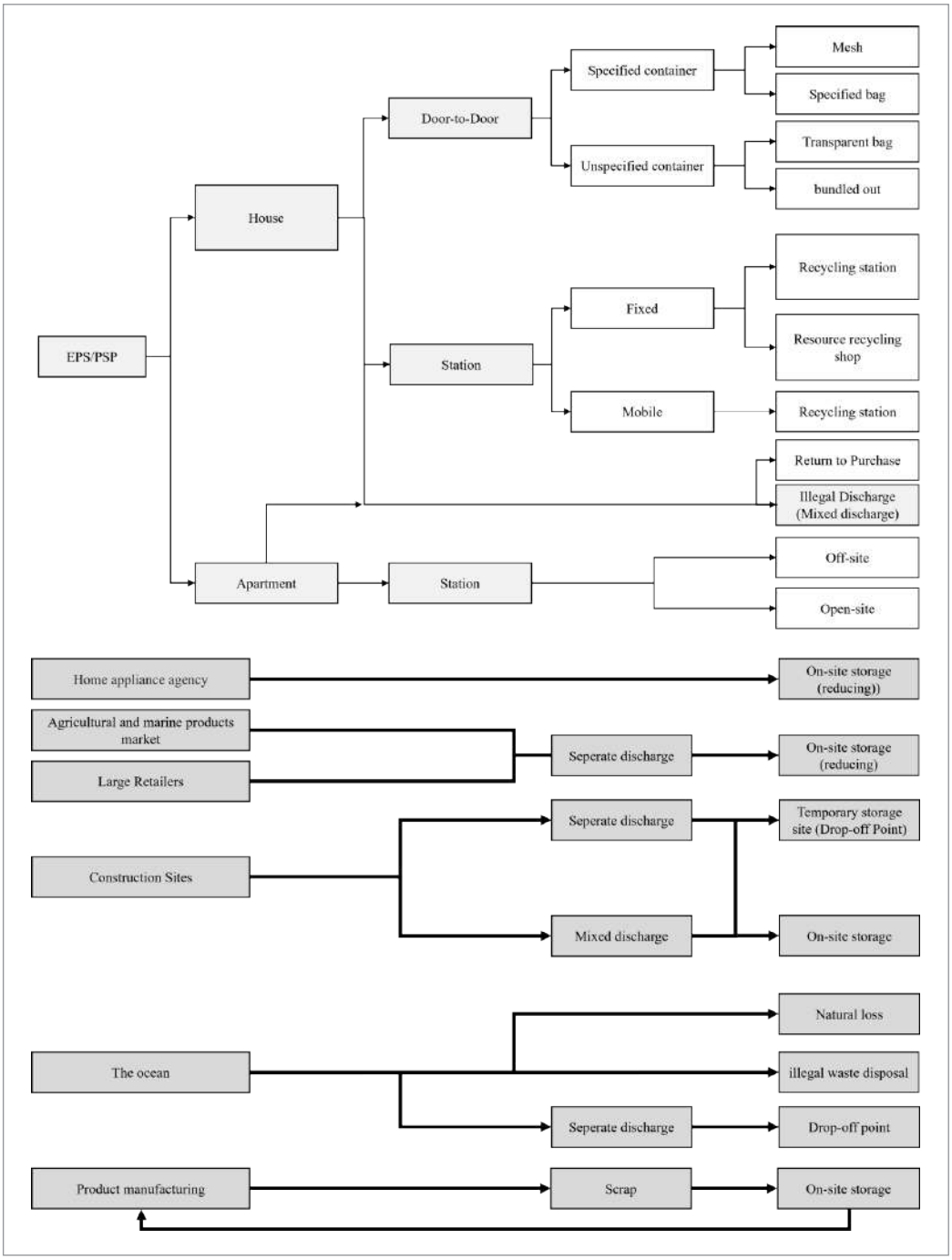
The places where the foamed plastic is discharged are large-scale companies, such as households, general workplaces, home appliance dealers, large distribution companies, and construction sites. Houses are collected in transparent bags or tied with strings and discharged by door-to-door and station discharge methods. Conversely, in apartment, foreign substances(tape, etc.) are removed. General workplaces are also discharged in the same way as houses, and boxes of agricultural and marine products, cup noodle containers, and food plates are mainly discharged. When a consumer purchases a product, home appliance retailers visit and install the product, discharge the buffer that packaged the product, and collect and dispose of it directly.

Large distribution companies and large-scale dischargers (agricultural and fishery markets, universities, funeral homes, stadiums, convenience stores, etc.) are to separate and collect foamed plastic for recycling under the 「Waste Control Act」. Accordingly, Garak-dong Agricultural and Fisheries Wholesale Market in Seoul and Nonghyup Hanaro Mart in Yangjae-dong are operating their own foamed plastic reduction facilities to produce and discharge ingots, simultaneously. Foamed plastic used for construction is treated as construction waste. Thus, it is generated from sandwich panels, insulation materials, and EPS blocks and is separately discharged. Buoys are either discharged to a station or lost.

[Table 4-22] Collector of EPS by source

Category		Item	Collector
EPS	Home Appliances	buffer, etc.	Home appliance company (distribution center)
	Agriculture and fisheries	Agricultural and fishery boxes, etc.	Local governments and private businesses
	construction	EPS block, etc.	
	Fishing	buoy	
	Oher	EPE, EPP	
PSP		Cup noodle container, saucer, fruit plate, etc.	

<Figure 4-22> EPS discharge system in Korea



<Figure 4-23> Discharge method by source

	
House (station)	House (door-to-door)
	
Apartment (station)	House and apartment (Volume-based bag, difficult recycling EPS/PP)
	
Agricultural and fishery market	Home appliance buffer(Return to dealer)
	
Construction materials	Buoy

② **Recovery and Recycling**

The separated and discharged EPSs are collected and transported by local governments, self-reduction, or private companies. The EPS collected by local governments are generally manufactured as ingots at the EPS reduction facility installed next to the sorting facility and then sold to private recycling companies. Self-reduced ingots and EPS recovered by private recycling companies are exported or manufactured into pellets and recycled as raw materials for various products. EPS has a large volume, and it is not economical to recover and recycle.

The main method for reducing EPS in Korea is mechanical reduction (thermal reduction and compression reduction), and some chemical reduction is used. The thermal reduction method extrudes by melting and extruding with friction heat and indirect heats using a heater, while compression is transferred to the SCREW. Ingots are directly used for product manufacturing or re-molded by extrusion to produce pellets, and the pellets are recycled as recyclables. The compression type produces block-type compressed products with a volume of 1/50 by crushing and compressing. It has no odor and is very simple to use. It has few failures and great durability. Chemical recycling can process all non-recyclable colored and contaminated EPS by dissolving them using a solvent and recovering them as recycled materials.

In-hwa Industrial, Dain Machinery, and Seho Engineering are the main manufacturers of mechanical weight reducers used in Korea, whereas Sherim Chop Mill Co., Ltd. is a manufacturer of portable weight reducers installed in vehicles. In-hwa Industry's reduction machine can maximize the work efficiency by a conveyor and reduce wet EPS. The heat reduction machine of Dain Machinery is applied, and it is possible to reduce the foamed plastics, such as EPS, PSP, and EPE, simultaneously, and has the advantage of being able to reduce the weight without pre-treatment of the attached tape. Seho Engineering's compression reducing machine has the advantage of being able to process all kinds of foamed plastics. Sherim Machinery's portable EPS reducer is reduced by compression by high-pressure steam and hydraulic pressure, and it reduces logistics costs and does not require a separate workplace.

The chemical reducer manufacturer is Tipple Co., Ltd., and there is no odor and fluid gas, which are the disadvantages of the existing technology. Even contaminated EPS can be recycled. It has the advantage of being recovered by dissolution, and 98% of the solvent can be reused.

[Table 4-23] Major EPS reduction facilities in Korea

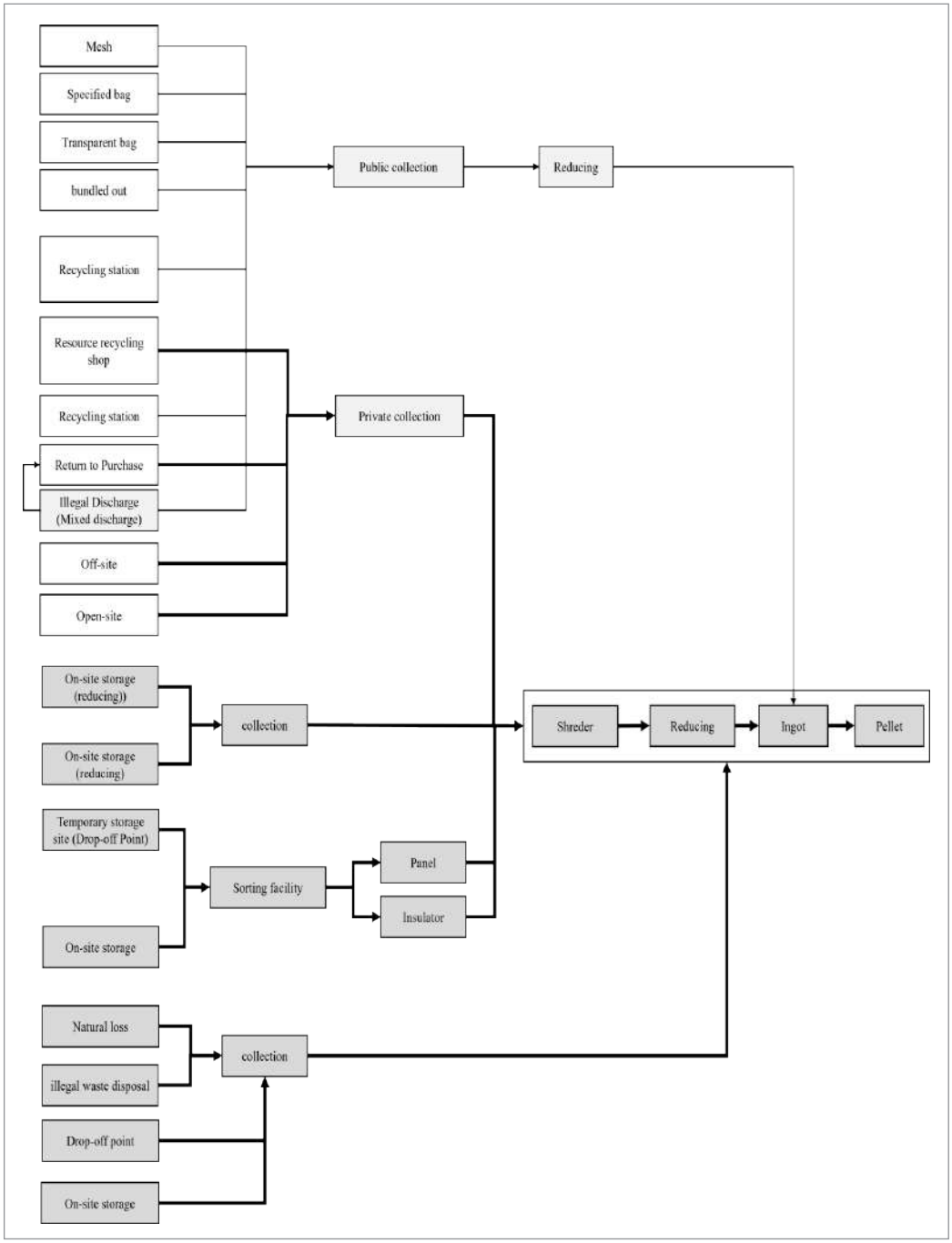
Category	fixed reducer		Mobile reducer
Manufacture	In-hwa Industrial	Dain Machinery	Sherim Chop Mill Co., Ltd.
Model	IA-200–750	D-290–495	-
Figure			
Manufacture	Tipple Co., Ltd.	Seho Engineering	-
Model	Tipple Plant	SH-C150	
Figure			

<Figure 4-24> Tiple's EPS reduction and recovery process

	
Input	Compression and Reduction
	
PS gel	Recovery and recycled resin manufacturing

To compensate for the cost reduction due to a decrease in the unit price of recycled materials and in the amount used by the demanding party, subsidies of 61–274 won/kg are provided for the foamed plastic resin. As a result, Korea's EPS recycling rate is 99%, and 194 EPS recycling companies are establishing a stable EPS recycling system.

<Figure 4-25> EPS recovery and recycling system in Korea

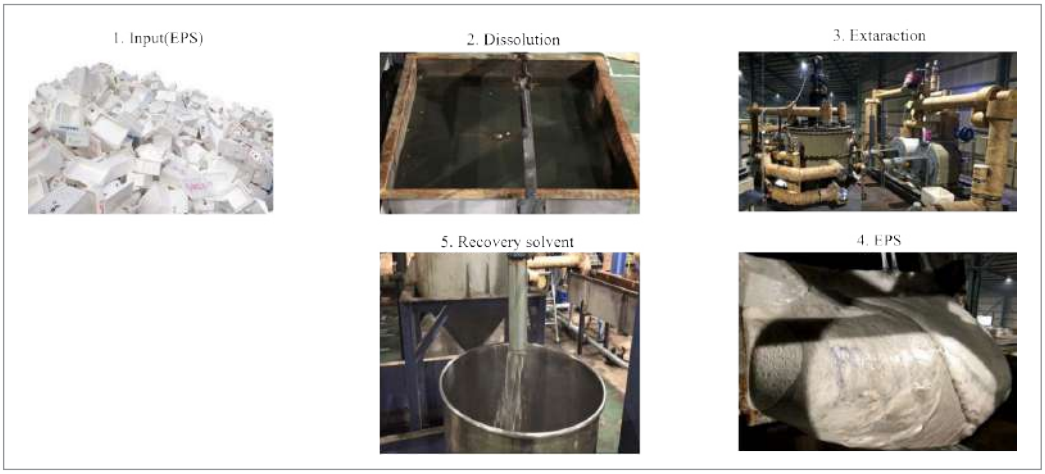


<Figure 4-26> EPS recycling process in Korea (1), Sangnok Development (Gyeongju-si Resource Recycling Center, Chungju-si Clean Energy Park)

<Figure 4-27> EPS recycling process in Korea (2), Flame-retardant EPS recycling company (Daewoong Resin)

<Figure 4-28> EPS recycling process in Korea (3), EPS recycling company (Taean-gun Environmental Management Center + Jinsung Tech (pellet manufacturing))

<Figure 4-29> EPS recycling process in Korea (4), Tipple plant



In Korea, most of the EPS are used to manufacture and export recycled materials in the ingot state or to produce frame moldings. Methods of manufacturing raw materials are classified into three types: physical, chemical, and thermal. The physical method is a method for recycling by crushing, crushing, or compression. The imported foamed plastic is pulverized and used as lightweight concrete or coating agent by high-strength extrusion or recycled in the form of compressed products. It is used mainly to produce ingots by melting crushed and pulverized products. It is also used as a raw material for other plastic products after being made into recycled materials by pelletizing.

The chemical method is used to dissolve polystyrene in a solvent and then recover it as a solvent and raw material. In the past, facilities for chemically recycling foamed plastics

using organic solvents were distributed, but there was a profitability problem due to the high cost of organic solvents. To solve this problem, companies have been researching to recover the solvent, but it has not been activated yet due to the high cost.

In the thermal recycling method, foamed Plastic is selected, kept in a dry state, and molded solid fuel is produced by perforating by high-temperature compression and mixing. However, solid fuel production is not preferred because of its short combustion rate.

[Table 4-24] Products using recycled EPS as raw materials

Category	Recycling method	Use
Recycled material	Pelletize waste EPS by pulverizing the ingot that has been first reduced in volume with an extruder, or pulverize waste EPS and put it directly into the extruder for palletization, followed by molding extrusion or product injection.	Extrusion: picture frame, bathroom scaffold, decorative cabinet, window frame Injection: video case, ballpoint pen stand, hanger, etc.
Coating agent	After crushing the waste EPS and mixing it with a chemical or natural solvent, it is related and used as a coating agent for non-woven fabrics, papers, etc.	Sneaker soles, suit wicks, waterproof paper, etc.
Lightweight concrete	After applying a pulverized product with a diameter of 5 mm or less as a coating agent, it is mixed with cement and water to use as lightweight concrete.	Light concrete, light aggregate, etc.
Molded product	Molding by mixing the pulverized product with fresh foamed granules	Insulation, packaging, etc.
Pyrolysis	Styrene monomerization by pyrolysis	Raw materials for EPS molded products, paints, and other chemical products.

In Korea, major EPS recycling companies include Eco Green, Dream E&I, M&Tech Co., Ltd. Seongnam Branch, and Jinsung Tech Co., Ltd. Although it was impossible to confirm the specific business model as a trade secret, the economic feasibility of the business was get by producing A-grade ingots or increasing the by put rather than whether the state of the recycled materials was pellets or ingots.

<Figure 4-30> Four major EPS recycling companies in Korea

Eco Green

Dream E&I

M&Tech Co., Ltd

Jinsung Tech Co., Ltd

3.2 PP recycling process

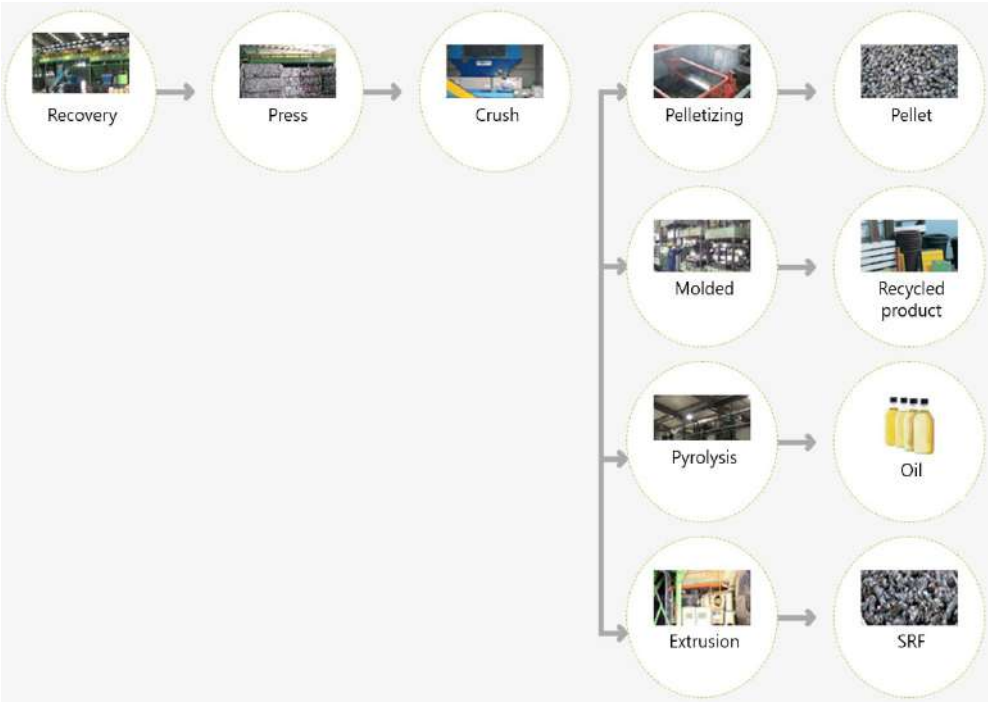
(1) Summary

Recycling statistics for PPs in Korea are being compiled with plastic containers (PE, PP, PS, etc.) and vinyl. Heat-resistant airtight containers, such as delivery and side dish containers, disposable straws, and plastic cups, are widely used as kitchen tools.

PP discharged from households goes by a separation and recycling facility and is manufactured into PP flakes and pellets. Most of the PPs discharged from the workplace are recycled as recycled materials because of their uniform and clean appearance. Most of the recycled materials are used in the manufacture of pallets.

<Figure 4-31> Plastic container recycling process

<Figure 4-32> Composite packaging materials, such as film recycling process



[Table 4-25] Overview of PP

Category	PP
Production method	• Propylene is produced by pyrolyzing hydrocarbons, such as petroleum or natural gas, and separating and refining them by boiling.
Main use	• Automobile, electronic device parts • Packaging film and packaging materials (including disposable products)
Generation of waste	• Home and restaurant • Waste vehicle recycling and electrical and electronic products, manufacturing/dismantling recycling company
System of recovery and recycling	• Local governments and private collection companies collect them from homes and businesses and sort/recycle them on their own or consignment • Production of flakes, pellets, and products (pallets, etc.)

Category	PP
Recycling method	• Pallet, car interior

b. Recycling Process

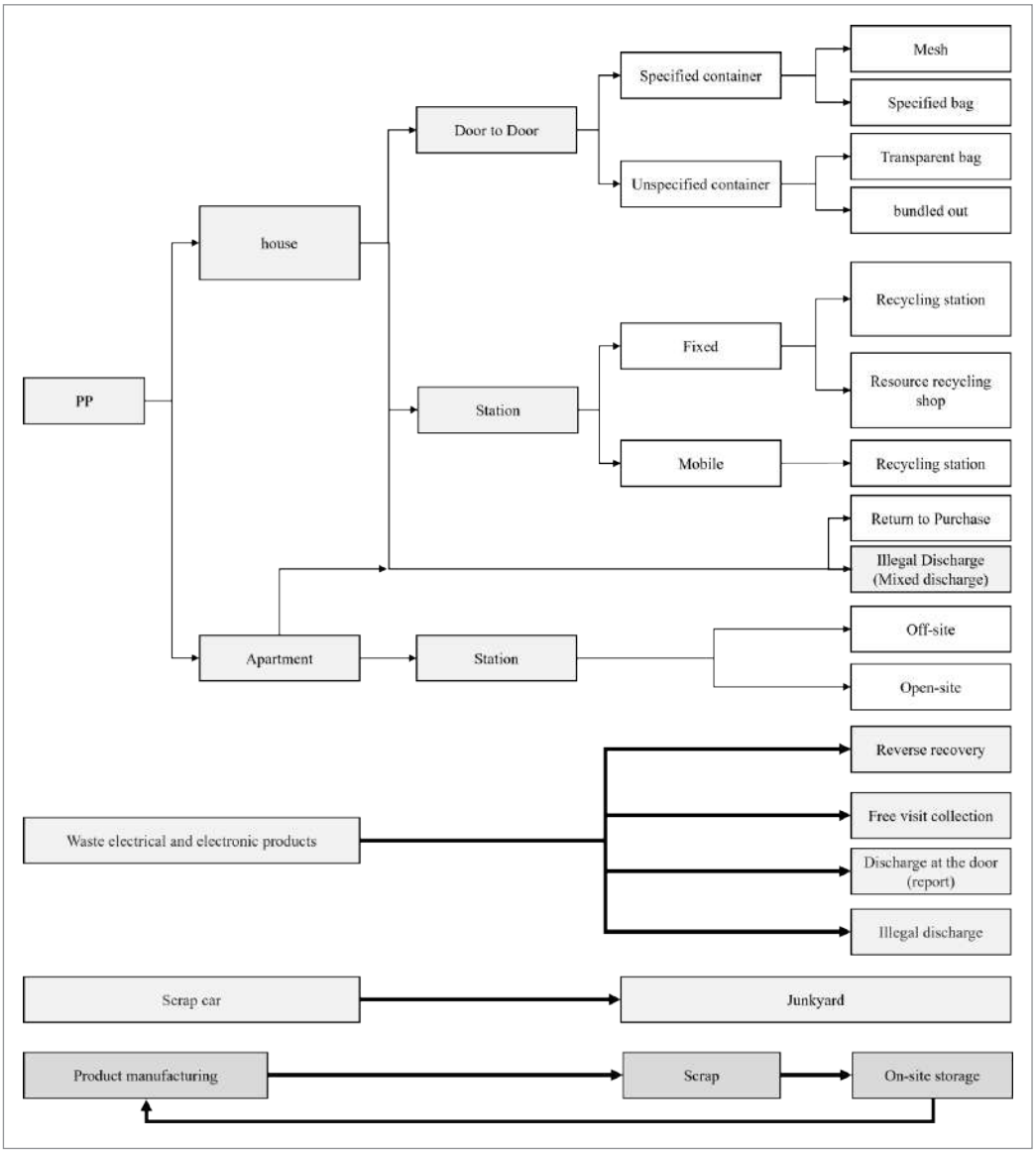
In Korea, the main source of PP is from packaging materials, manufacturing, and recycling of scrap cars and home appliances generated at homes and general workplaces. The recycling process by the source is divided into the discharge stage, the recovery and transport stage, and the recycling stage.

① Discharge

In households and general workplaces, PP is separated and discharged as plastic. Plastics are discharged after removing other materials from the body, such as trademarks and accessories. Also, plastics contaminated with foreign substances are difficult to recycle, so empty the contents and rinse with water before discharging.

A large amount of PP is generated from waste electrical and electronic products and waste automobiles. Two ways to collect waste electrical and electronic products are: reverse recovery at home appliance dealers, free discharge, and reporting to local governments. Additionally, there are cases where they are discharged illegally, which junk dealers collect. When a scrap car is reported to be scrapped, a scrap car driver tows the vehicle to a junkyard and pays compensation for the scrapped car.

<Figure 4-33> PP discharge system in Korea



② **Recovery and Recycling**

PP discharged from homes is transported to public and private sorting facilities as mixed plastics. The transported plastics are manufactured into compressed sorted products using materials (PET, PE, PP, PS, and OTHER) by a comprehensive sorting process. After breaking the plastic packing recyclable resources by a breaking machine, a ballistic separator separates the low-density vinyl from the high-density metal cans and glass bottles. Plastics go by an optical sorting machine and are classified according to the plastic material.

The bag-breaking machine is a facility that tears the recycled bags, etc., with several rotating blades mounted on the inner rotating shaft. It is installed in the waste input part of the sorting facility to make the waste into a size suitable for the process and to supply a certain amount to make a smooth process flow in the sorting line. Korean companies and equipment related to breaking machines include Dawon Industrial's waste recycling breaking machine, ACI's breaking bag machine, and Mntech's breaking machine, which provides a breaking rate of over 95%.

[Table 4-26] Korea's major recycling and sorting facilities

manufacturing company	Dawon Industrial	ACI	M&Tech.
Capacity(t/h)	12	50	45
Break rate (%)	95	96	95
Performance	Guri, Anyang, Anseong, Okcheon, Seosan, Asan, Jecheon, Jungnang, Pocheon, Yongsan, Pohang, Gyeongju	Geoje, Guro, Chungju, Seongdong, Dobong, Wonju, Jeonju, Tongyeong	Masan, Sejong, Buyeo, Jangsu, Jecheon, Seosan, Uiwang
Fig			

The ballistic sorter is an equipment that separates wastes by specific gravity by elasticity and separates 3D materials, which are containers, and 2D materials, which are vinyl. High-density and large-size wastes are sorted by moving downwards with the action of the paddle, while low-density and flat wastes (vinyl and paper) are moved upwards and sorted. Korea's ballistic sorter-related companies include Daehan E&C, ACI, and M&Tech.

[Table 4-27] Korea's main bag-breaking machines

manufacturing company	ACI	M&Tech.	Daehan E&C
Capacity(t/h)	23	63	1.30
Performance	Gongju, Gimcheon, Yeongju, Siheung, Jeonju, Sejong, Namwon, Seongdong, Yanggu, Chungju, Tongyeong, Asan, Wonju, Dobong, Yeoncheon, and Seosan	Masan, Sejong, Buyeo, Jangsu, Jecheon, Seosan, Uiwang	Cheonan
Fig			

In Korea, plastic sorting and optical sorting technologies are used as sorting methods, and the recent modernization of optical sorting technologies is expanding the spread of optical sorting technologies. It is a method for irradiating near-infrared rays on the plastic passing over the conveyor belt, analyzing the wavelength of the reflected light to identify the type of plastic, and then separating and sorting the plastic by computer control. However, in the case of black plastic, even when near-infrared rays are irradiated, the reflected light does not come out properly and is absorbed, so the near-infrared sorting cannot be used. This principle is being used as a plastic sorting technology in Korea, and it is used to classify PET, PP, PE, and PS materials. Domestic optical sorter-related companies include ACI, M&Tech., and Ioniant.

[Table 4-28] Korea's main optical sorting machine

manufacturing company	ACI	M&Tech	Ioniant
Capacity(t/h)	14	-	5
sorting rate (%)	90–95	90	90–95
Performance	Suncheon, Gimcheon, Yeongju, Seogwipo, Siheung, Yecheon, Jeonju, Sejong, Gwangju, Guro, Yangsan, Namwon, Pyeongchang, Tongyeong, Geumsan, and Yeoncheon	Ansan, Uijeongbu, Masan, Sejong, Buyeo, Jangsu, Jecheon, Seosan, Uiwang	Miryang, Yangju, Yangpyeong, Paju, Gimhae, Sasang, Yangpyeong, Suwon, Seosan, Gwacheon, Hwaseong, Gangnam, Buyeo, Cheonan, and Sejong
Fig			

PP containers go by sorting, compression, crushing, washing, melt extrusion, and material recycling to make pellet-type recycled materials. However, few companies manufacture and sell recycling equipment in Korea. This is because most of them are made from flakes or purchased and used cheap Chinese pelletizers. ACI is also supplying the products of Biffa, not its products.

Eco-Creation uses the principle of fractional distillation to extract high-quality and high-purity oil, and get the technology to separate highly volatile naphtha to extract stable oil.

[Table 4-29] Korea's main pelletizer or Pyrolysis

ACI	SM chemical
	

After the waste home appliances brought into the recycling center are sorted by product, they are manually dismantled and sorted by material. Pre-treated wastes are crushed and recovered as metals and plastics. The plastics mainly used in electrical and electronic products are ABS and PP, and they are selected using the difference in specific gravity. The screened PP is dried and molded to make pellets.

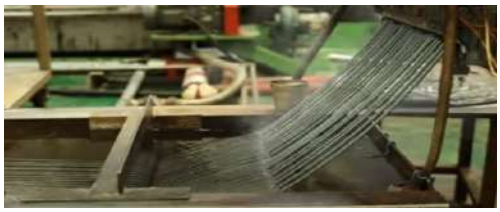
<Figure 4-34> PP sorting and recycling process for home appliances

Predisposal (sorting and dismantling)

Crush

Specific gravity sorting and cleaning

Dry



Pelletizing

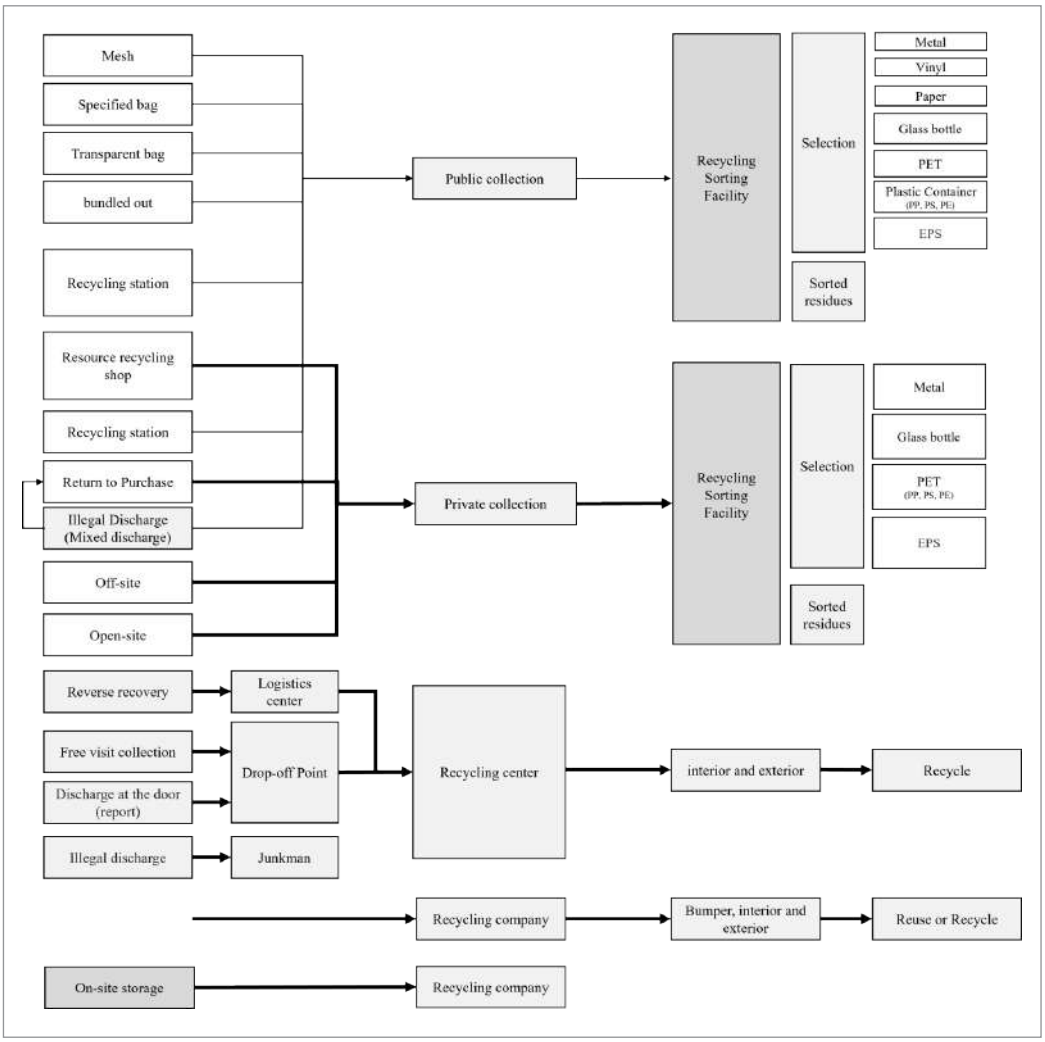
Approximately 800,000 vehicles, or 20% of production, are scrapped yearly in Korea. When a scrap car is brought in, it is first disassembled into about 40 reusable parts (bumpers, bonnets, tires, etc.). At this time, the bumper and interior and exterior materials are mainly made of PP material. After crushing the waste bumpers or interior and exterior materials, foreign substances, such as paint, are removed, melted, and pelletized to produce recycled

materials. However, shredded vehicles are incinerated and buried because various plastics are mixed, and there is no economic feasibility of sorting.

<Figure 4-35> PP sorting and recycling process from scrap cars

	
Pre-treatment (disassembly)	Waste plastic (bumper shredded product)
	
Paint removal	Melting and pelletizing

<Figure 4-36> PP recovery and recycling system in Korea



05

CHAPTER

To-Be Model for transitioning to a Circular Economy

1. Proposal EPS-PP resource circulation model
2. Roadmap for Establishing a Resource Circulation Model for Ecuadorian EPS and PP

To-Be Model for transitioning to a Circular Economy

1. Proposal EPS-PP resource circulation model

1.1 What is needed in Ecuador to establish the EPS and PP resource circulation model

To propose Ecuador's EPS-PP resource circulation model, the levels of the two countries were compared. Since Ecuador has a lower population density than Korea, it is difficult to secure the economic feasibility of the waste treatment business. Comparing GDP, it is one-tenth of Korea's, but the environmental budget is one-half. This means that it is difficult for the Ecuadorian government to get an appropriate budget for waste management. Therefore, it is necessary to create a plan that enables private-led projects.

The country's waste collection rate is not low. However, the proportion of separate discharges is low (33.6%). This means that separate discharge has not been established yet, so a plan to induce citizens to separate discharge is needed.

Ecuador wants to improve its recycling process. There appear to be many companies for waste collection, transport, and disposal. However, since the recycling rate is only 6%, it is considered a disposal facility rather than recycling. This means that the infrastructure for recycling has not been established, so there is a need for measures to foster the recycling industry. The current waste treatment system in Ecuador consists of collection > separation > (sales) > or grinding > cleaning > (sales). Therefore, technical improvement in waste screening is needed in Ecuador, and the cost is the most significant issue to consider.

There are no separate data for EPS and PP, the subjects of this study. This means that the above wastes are not managed. It is necessary to establish a statistical system for waste management. Also, with the right direction and incentives from the involved actors, it can be translated to EPS and PP.

[Table 5-1] Comparison of Economic Size and Waste Treatment Infrastructure of Korea and Ecuador

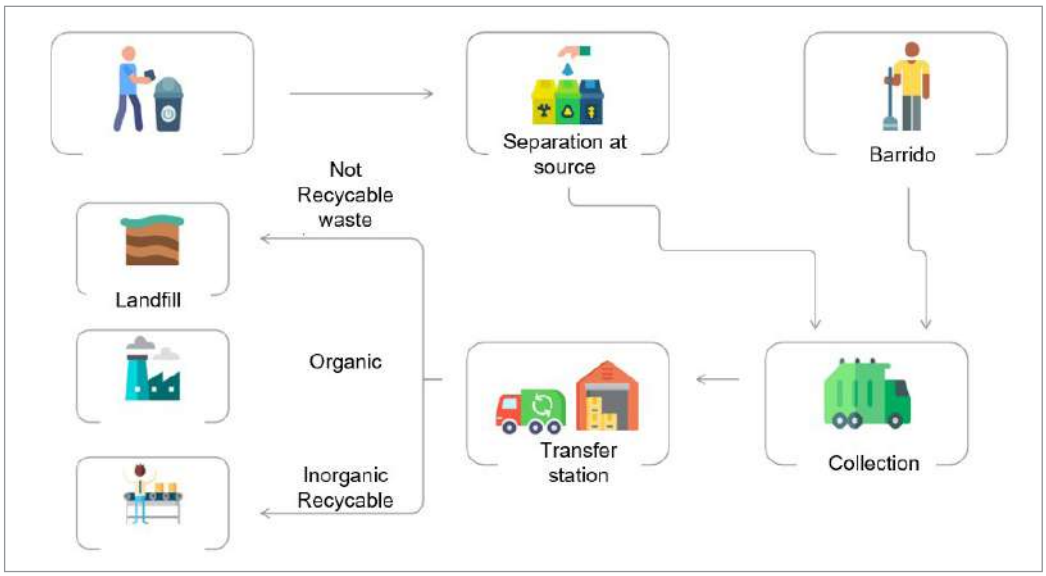
Category	Ecuador	Korea
Size (km2)	283,560	100,210
Population	17,640,000	51,780,000
GDP (million USD)	98,810	1,631,000
GDP (million USD/per)	0.0056	0.0315
MSW (ton/day)	14,400[1)]	61,766
MSW(kg/capital·day)	0.83[2)]	1.16
Plastic of MSW (%)	11.0[2)]	19.6
Recycling rate of MSW (%)	6[1)]	59.5
National budget in 2020 (million USD)	35,498	397,892
National budget for AMBIENTE (Environment) in 2020 (million USD)	227	6,994
Budget for management of MSW in Local gorvernment (million USD)	N/A	5,728
National Collection rate (%)	87.5[2)]	99.4
Municipalities of separate discharge (%)	33.6[2)]	100
Transport company	more than 2,000[1)]	Public: 232 Private: 722
Collection company	more than 500[1)]	
Recycling and treatment company of MSW	approximately 200[1)]	Sorting of Public: 242 Recycling of Private: 173
EPS recycle rate (%)	N/A	Packaging(`20): 99.3% Shipment: 51,150 ton Recycling: 50,807 ton  Buyo(`15): 23.8% Shipment: 2,021 ton Recycling: 478ton Construction(`21): 11.3% Shipment: 129,722 ton Recycling: 14,684 ton  Plastic(`20): 61.8% Waste: 10,303,099 ton Recycling: 6,370,617 ton
Plastic recycle rate (%)	N/A	

1) Holland cicular hotspot, Waste Management Country Report: Ecuador, 2021

2) Estadística de Información Ambiental Económica en Gobiernos Autónomos Descentralizados Municipales Gestión de Residuos Sólidos 2020.

There is no problem with Ecuador's waste treatment system itself. However, it is considered that there are problems in that the recovery amount is small due to poor separation and discharge. Sorting is also difficult, lowering the economic feasibility of recycling.

<Figure 5-1> MSW treatment process in Ecuador



The table below divides Ecuador's current situation, problems, and improvement plans.

[Table 5-2] Situation, problems, and solutions for EPS and PP

Current situation	Problem	Solution
It is difficult to check the amount of plastic waste generated by waste statistics	Lack of objective data for plastic management	Waste management and statistics building
Lack of finance for the recycling process	Difficult to expand recycling infrastructure due to financial burden	Introducing systems for financing and introducing recycling infrastructure. For example, EPR, Waste charge system, and volume-based fee system
Low environmental awareness of the people and businessmen	Loss of driving force in the recycling industry due to the insufficient separate discharge and green consumption	Reinforcement of civic awareness by eco-friendly consumption and obligatory purchase.
Private companies have not come in	There is a limit to fostering the recycling industry only with the government's efforts	Activate private companies by presenting a recycling business model. For example, EPR, waste statistic, and eco-design

1.2 Proposal EPS-PP resource circulation model

(1) Manufacturing

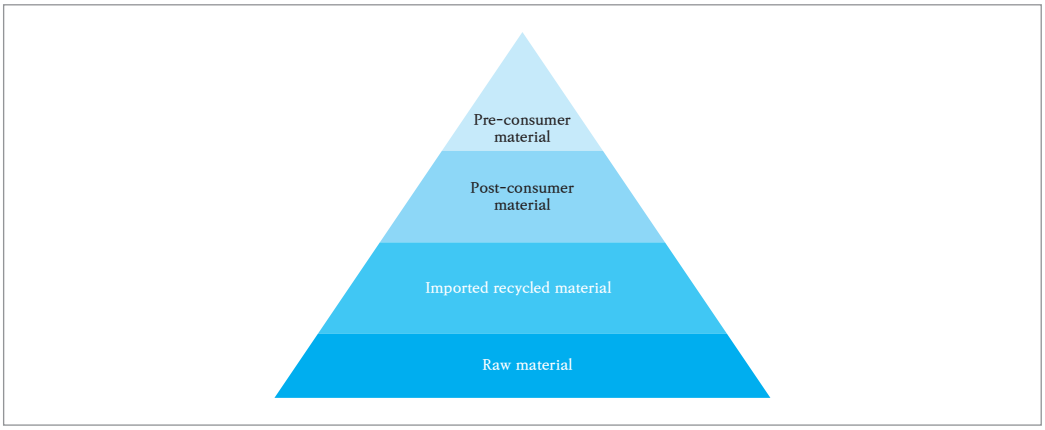
In the manufacturing stage, products should be produced to be easily discharged, sorted, and recycled. Korea is improving the recyclability of products by the structural evaluation system for packaging materials or the cycle availability evaluation. However, it was highlighted as a problem because it did not reflect the difficulties of the separate discharge or recovery process and it focused on the impact on the recycling stage. Accordingly, it is reasonable for Ecuador to establish the material structure standards for products and consider the ease of discharge and sorting, and introduce the material structure system to make it legally obligatory.

Since Ecuador does not have a developed chemical refining industry, it is necessary to actively utilize renewable and imported raw materials. Importing waste is not a negative thing. With the recent rapid growth of the PCR industry, it can be an opportunity to contribute to the eco-friendly plastics industry by importing, recycling, and reselling waste plastics.

Therefore, it is necessary to prioritize the use of recycled materials. It must be used in the order of the scrap generated during the manufacturing process, waste reduction and self-recycling, post-consumer recycled materials, imported recycled materials as a priority, and new material as a last resort. This was to foster the resource recycling business in Ecuador and establish a stable disposal system but allowed imports in case raw materials were insufficient.

Korea's waste charge and EPR systems were used as economic incentives to use recycled materials to manufacture EPS and PP. Producers should be encouraged to use recycled materials. The waste levy system is a type of plastic tax concept. When new materials are used, a tax is levied according to the amount of output, and the amount of recycled materials used is excluded from the amount of output, and the tax is imposed. As the producer-responsible recycling system supplements the recycling economics of EPS, it will be possible to prepare financial resources to establish recovery and recycling systems. Since new materials may be used when oil prices fall, it is necessary to ensure that more than 30% of recycled materials are used by making the use of renewable materials obligatory.

<Figure 5-2> Priority of use of plastic materials



In Korea, the system related to recycled products could ineffectively induce companies to use recycled materials. This is because using high recycled materials (40% of product weight, etc.) was obligatory to be recognized as a recycled product. Therefore, if recycled content is used, even by a company even at 1%, the history can be marked on the product, so it is possible to actively promote the use of recycled materials. If recycled content is used in packaging materials, you can receive mileage when purchasing recycled products, depending on the content. When using recycled materials instead of new materials, the reduction in greenhouse gas discharges can be recognized as the user's performance, and environmentally conscious consumers can manage green management. There are various advantages of purchasing products and mileage from companies that implement.

To measure the content of specific recyclable resources, you can refer to the guidelines for recycling content of plastic packaging materials published in the UK. In the UK, measuring the content of recyclable resources based on the material balance is recommended. Mass balance is the consideration of the inputs, outputs, and distribution of substances in a process or step, from pre-defined system boundaries and within a specified period (usually one year) to outputs (i.e., products with recycled content) to inputs (i.e., products with recycled content). It is applying a method that matches the amount of recycled feedstock. Thus, it is necessary to review the introduction of recycled content based on the mass balance in Ecuador.

Since recycled materials have undergone recycling, their function and environmental properties are inevitably lower than those of new materials, so quality standards that guarantee this are necessary. To promote the recycling industry of recycled materials, a separate quality standard should be prepared considering the status of Ecuador's plastics industry. There is no quality standard for recycled PS in Korea, and KS M 3843 is stipulated

as the KS quality standard for PP-recycled materials. The regulations classify PP into four types and stipulate the quality standards as follows.

[Table 5-3] PP Recycled Material Quality Standards in korea

Type	Contents			
	melt mass flow index (g/10 min)	tensile strength (MPa)1)	Izod Impact Strength (KJ/㎡)	Ash (%)
PP(R)-1	<2.0	16.7≤	0.490≤	suggested by the manufacturer or supplier
PP(R)-2	2.0 < X < 4.0	16.7≤	1.47≤	
PP(R)-3	4.0 < X < 8.0	16.7≤	2.94≤	
PP(R)-4	X ≥ 8.0	16.7≤	5.88≤	

Note 1) Tensile strength refers to the tensile stress at the maximum tensile load.

Conversely, in China, the quality standard for PS recycled materials includes eight items, including the content of foreign substances. Since there is no quality standard for PS in Korea, we proposed a method to apply the Chinese standard. In the relevant quality standards, relatively high-quality items are given a premium, and those that satisfy the minimum standards are defined as passing products. Thus, they are classified into grades 1 and 2. The standard for PS-I, an impact-resistant polystyrene, is also prepared by subdividing PS.

[Table 5-4] PS Recycled Material Quality Standards in China

Category			Unit	PS(REC)	
				Premium (Level 1)	Passed product (Level 2)
1	External matter content		g/kg	≤150	≤150
2	Ash(600°C ± 50°C)		%	≤1	≤3
3	Water contents		%	≤1	≤1
4	Density	Measures	g/㎤	M1*	M1*
		error	%	±0.005	±0.006
5	melt mass flow index		g/10 min	≤30	>30, ≤70
	Melt Mass Flow Index Coefficient of Variance		%	≤20	≤20
6	tensile strength		MPa	≥18	/
7	Izod Impact Strength		KJ/㎡	≥1.0	≥1.0
8	Vicat softening temperature		°C	≥80	≥80
9	Residual styrene monomer content		mg/kg	≤500	≤500

** M1 is a measure of density*

[Table 5-5] Contents and benefits at the manufacturing stage

Contents	Benefit
Eco-design	• Easy sorting and recycling due to simplification
Priority setting for the use of recycled materials	• Suppression of new reuse and promotion of the use of recycled materials * To revitalize Ecuador's plastics industry, it is also necessary to foster the recycling of waste plastics. • Promote the use of recycled materials by producers
EPR and Waste charge system	
Obligatory use of recycled materials	
Quality standards of recycled material	• Enhancement of functionality and reliability of recycled materials

(2) Discharge and Recovery

Discharge is very important for the recovery of recyclables. Ecuador's EPS discharge sources are classified into small/large-scale discharge sources. Small-scale discharge sources are classified into downtown, island, and mountainous areas, and large-scale discharge sources are divided into agricultural and fishery wholesale markets, home appliance dealers, large distribution companies, and large-scale discharge companies. A model should be prepared to settle separate discharges for each source.

In Korea, there are many cases in which foreign substances are bound to EPS from households, such as tape or a waybill, or the contents are attached and discharged. Most EPS are made and sold in the form of ingots, and it requires a lot of labor to remove the tape and contents before reducing the size. In Korea, a weight-reducing machine treats such tapes and foreign substances, but it still causes a problem as the quality of ingots deteriorates. Therefore, there is no choice but to thoroughly exclude it in the separation and discharge step or to use a chemical-reducing equipment in difficult cases. In the case of PP, recycling is difficult if it is contaminated with food waste. In Korea, this is stipulated in the guidelines for the separate collection of recyclable resources, etc.

As for the discharge method, the door-to-door discharge method and the station discharge method can be considered. In Korea, door-to-door discharges account for 82.4% because this is a convenient method for the discharger. However, the door-to-door discharge has the problem of excessive collection and transportation costs, making it difficult to create profitability. Due to this problem, in Korea, there are very few cases in which the private sector deals with house areas where door-to-door discharges are the most. Since the station discharge method can discharge at all times, the convenience of discharge for residents can be greatly increased. Additionally, it is easy to collect and transport recyclables due to discharge at a designated location.

Therefore, compared with door-to-door discharge, station discharge is more advantageous for effectively using recyclable resources. Since the reduction equipment is used in the recovery process, it is reasonable to apply the station discharge mainly to the area where the equipment is installed. In the case of Korea, the introduction of a recycling station in Jeju City has been proven to reduce the number of collection vehicles by seven, the number of collection workers by 33, labor costs by 2,226 million KRW, and vehicle maintenance by 94 million KRW. It was found that collection costs can be reduced by 22% and greenhouse gas discharges by 16%. However, there is a possibility that difficulties may arise in selecting the discharge site and managers. Additionally, there is a risk of lowering recycling if the correct separation of discharge, proper management, and collection are not supported.

[Table 5-6] Comparison table of door-to-door and station discharges

Division	Door-to-Door	Station
Outline	• The waste discharged in front of the house is directly collected by the environmental sanitation agency and transported to the disposal facility using a collection vehicle.	• The discharger directly brings waste to the designated place (base) and discharges it, and the environmental cleaner collects and transports the waste at the base
Advantage	• High convenience in discharging • Easy to detect illegal and mixed discharge cases of discharger	• Promotion of separate discharge of recyclables • Low cost of collection and transportation
Disadvantage	• Illegal and unauthorized dumping • High collection and transport costs	• Difficulty in selecting a discharge site

In Korea's experience, there were many difficulties in settling in the early stages of segregation due to reliance on voluntary discharge. To settle this, a volume-based system was implemented to separate general waste from recyclables. Since then, efforts have been made to legislate the obligatory separation of waste, publish related guidelines, and encourage local governments to substantiate the separate discharge of recyclables. However, to separate and dispose of discharged recyclables, resource recycling shops, resource management assistants for each base, and CCTV installation methods that enable real-time status transmission have been used.

The Korean government is operating a mobile app "Separate Disposal in My Hands," which easily informs you of how to properly separate and dispose of recyclables. The Korea Environment Corporation, under the Ministry of Environment, which oversees the Producer Responsible Recycling (EPR) system, the Korea Packaging Recycling Business cooperative, and the Korea Recycling Resources Distribution Support Center, jointly participated in the production.

At the recycling shop, if residents bring recyclables, they will be compensated with cash or local currency, depending on the weight. Aluminum cans cost 560 won per 1 kg, plastics cost 105–200 won, and paper costs 49 won. The amount of compensation may vary according to the fluctuations in oil prices. However, recyclable waste must be "emptied, rinsed, and separated properly." Settlement is performed monthly, but you can check the settlement amount in advance by installing the "Eco Together app" on your cell phone. The compensation is paid by a recycling company that collects and distributes recyclables. Each store operates 1–2 days weekly, and 3–5 civic activists are assigned to each store to help collect recyclables.

The Korean government is implementing a resource management assistant system to support the correct separation of waste and to produce high-quality recyclables. The helpers for apartments and houses play the role of separating in advance the items that can be recycled and those that cannot be recycled among the recyclables brought by residents from the discharge site. Additionally, the proper separation method is explained to the residents, and publicity is conducted on the separate separation system for transparent plastic bottles. Conversely, in the case of a sorting site assistant, he/she works at a sorting site that sorts recycled waste. By this, approximately 3,000 tons of foreign substances and non-recyclable items were removed in advance from the apartment monthly. Additionally, 94% of the residents and 89% of the management offices were satisfied with the project.

Additionally, starting this month, 'collection daily for each item' has been implemented to increase the recovery rate of recyclable resources emitted from houses and shopping malls. If an item is disposed of on a date other than the discharge date by item, it is not collected. The reason for introducing the daily collection by item is that the efficiency of work has greatly decreased due to the process of collecting and re-sorting by vehicle first, as there are more cases of mixing and discharging items containing pollutants and various types of items.

<Figure 5-3> Cases of Efforts for Separate Discharge in Korea

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Obligatory separation and publicity</td><td>Resource recycling shop</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Resource management assistant</td><td>Installation CCTV at the Station</td></tr>
</table>

The main dischargers of houses, apartment, and island and mountainous areas are ordinary citizens. To promote separate discharge, it is necessary to implement a volume-based fee system, promote and obligate separate discharge, supply resource recycling shops and stations, provide resource management assistants, and install and distribute CCTVs.

Additionally, intensive recovery is required for those who discharge in large-scale, such as agricultural and fishery markets, large distribution stores, construction sites, and aquaculture companies.

A large amount of PP can be recovered at scrap car recycling companies and waste electrical and electronic product recycling companies. Therefore, it is necessary to consider establishing a recycling center for the product group and recovering raw materials from the product. It would be desirable to implement this by reflecting on the experience in Korea.

[Table 5-7] Promotion mehthod of separation and recovery of recyclables waste

<table>
<tr><th colspan="3">Source</th><th>Discharger</th><th>Promotion method</th></tr>
<tr><td rowspan="4">Small discharge source</td><td rowspan="3">City</td><td>House</td><td>Citizen</td><td rowspan="4">• Implementation of the volume-based waste system
• Promotion of separation and Obligatory
• Dissemination of resource recycling shops and stations
• Resource management assistant (including CCTV installation)
• Dissemination of recycling and sorting facilities</td></tr>
<tr><td>Apartment</td><td>Citizen</td></tr>
<tr><td>Workplace</td><td>Discharger</td></tr>
<tr><td colspan="2">Rural areas, Islands, and mountains</td><td>Citizen</td></tr>
<tr><td rowspan="6">Massive discharge source</td><td colspan="2">Agricultural and marine products market</td><td rowspan="6">Discharger</td><td rowspan="2">• Obligatory waste reduction and recycling</td></tr>
<tr><td colspan="2">Large Retailers,</td></tr>
<tr><td colspan="2">distributor</td><td rowspan="2">• Obligatory separation of construction waste</td></tr>
<tr><td colspan="2">Construction site</td></tr>
<tr><td colspan="2">The ocean</td><td>• Prohibition of use of sources
• Fishing buoy deposit system</td></tr>
<tr><td colspan="2">Product manufacture and recycler</td><td>• EPR</td></tr>
</table>

① **EPS**

Since EPS is light in weight and large in volume, it is necessary to supply a reducer to the discharge source. However, since it is difficult to supply the initial reduction equipment, an entry-level is required. Therefore, Ecuador's EPS discharge types are proposed as entry-level, fixed, and mobile.

The introduction of fixed and mobile reduction equipment is as follows. In the case of the fixed type, a compression type reducer of Dain Machinery and a press type EPS reduction machine from Tipple were proposed. Tipple's press-type weight reducer can handle most of the waste EPS, such as colored EPS that cannot be recycled conventionally, individual fruit packaging materials and cushioning materials, cup noodles, lunch boxes and foreign substances contamination, coated white EPS, and construction material EPS. Moreover, because there is no generation of environmental pollutants, it is possible to reduce labor costs mainly for plants and to produce high-grade plastic raw materials. In areas where a fixed installation is not economical, it is reasonable to introduce a portable reduction equipment in Hong Kong.

For the separate discharge and recovery of EPS, Korea's separate discharge labeling system and Japan's mass-discharge source management method can be considered benchmarking. Ecuador already has guidelines for separate discharges, but their

institutional effectiveness is low. Therefore, there is a need to improve civic awareness simultaneously as an obligatory separation of waste.

Unlike Korea, Japan is more active in recovery efforts than Korea, as cooperatives are required to pay a portion of equipment installation costs as subsidies when certain conditions are met. To this end, it is necessary to provide a subsidy for the recovery and recycling of the cooperative and the sale of equipment by recycling companies. Additionally, if the business model of Inco Recycling in China is used rather than just supplying equipment, it is expected to positively encourage the participation of private sector operators. it is possible to promote the sales of the reduction equipment.

Among the reduction techniques, in the case of the fixed type, it is applied to cases that occur continuously in a fixed place. In the fixed type, mechanical (compression and crushing) and chemical methods are used. Among the fixed mechanical reduction equipment, if the discharger puts waste-foamed plastic in the reduction container, the volume can be reduced to 1/50 level by mechanical disposals, such as pulverization and crushing. However, since the properties of PS change after physical reduction, it is difficult to convert back to foamed plastic, and most of them are recycled as PS moldings and picture frames. Therefore, it is a reduction technology unsuitable for the Package-TO-Package method, and resource circulation is possible only after establishing a recovery system for PS molding and picture frame products.

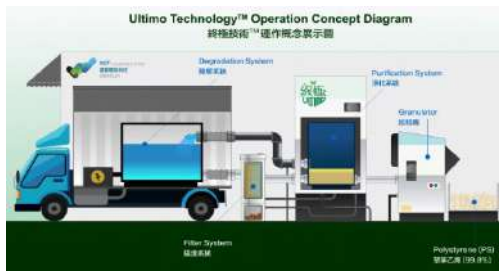
<Figure 5-4> Fixed type EPS reduction equipment

General type	General type
	

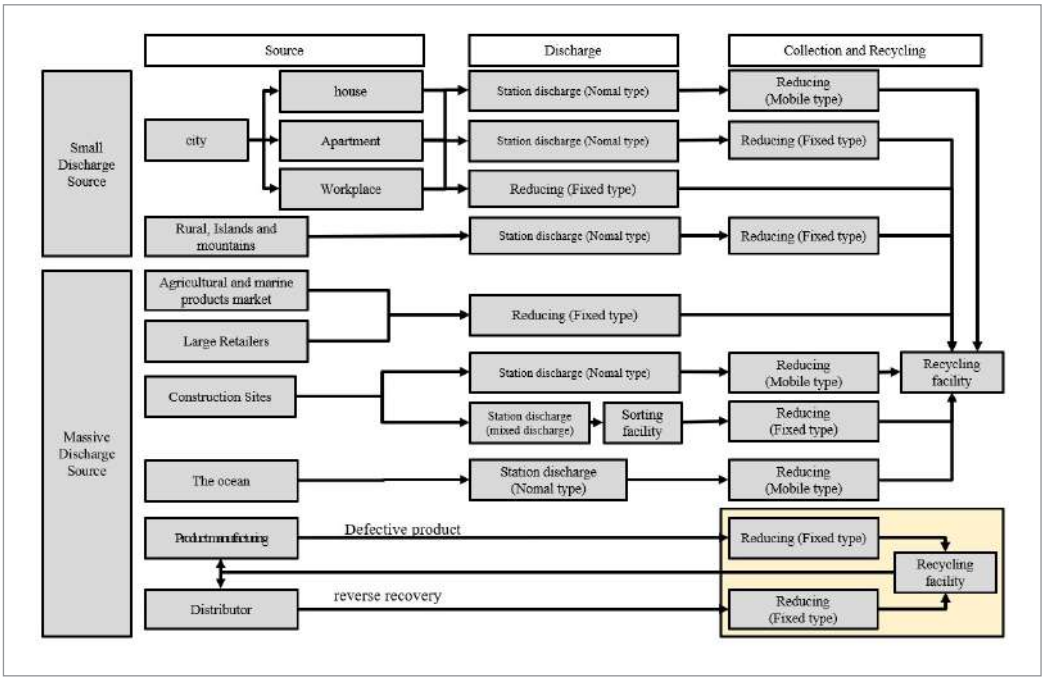
Fixed (mechanical)	Fixed (chemical)
	
	

In the chemical reduction equipment, when the discharger puts the waste EPS in it, it is converted into a liquid gel, the recycler collects it, and refines it, reproducing it with recycled materials and solvents. The mobile type is used when the discharge source is unspecified, and it is possible to produce EPS, a raw material, by separating it into a recycled material and a solvent in a recycling plant in a gel state in a vehicle. Since EPS has properties similar to PS resin, it can be produced again as a foamed plastic.

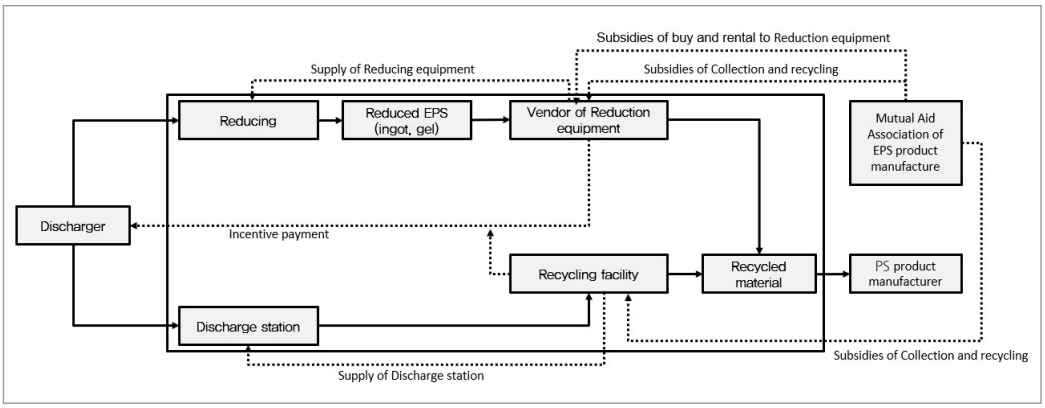
<Figure 5-5> Mobile type EPS reduction equipment

Mobile (mechanical)	Mobile (chemical)
	

<Figure 5-6> EPS discharge and recovery model of Ecuador



<Figure 5-7> EPS business model



② **PP**

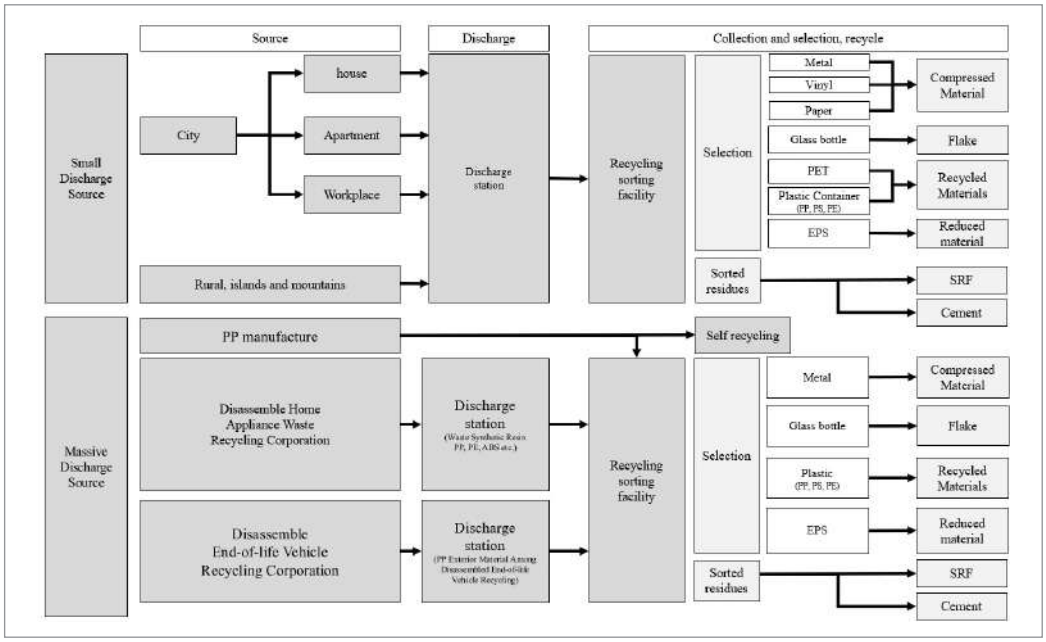
PP is mainly used for film and extrusion, and it is proposed to separate discharge based on station discharge and recovery by a sorting facility.

PP discharged from small-volume sources is separated and discharged by a recycling station, and is treated at a recycling sorting plant. Private business operators can minimize collection and transport costs as well as minimize contamination or mixing of selected items by station discharge and day-of-week collection methods. Additionally, considering the interest that the quality of recycled materials is good when selection is smoothly preceded,

there is an effect that can improve the selection efficiency and the quality of the recycled materials.

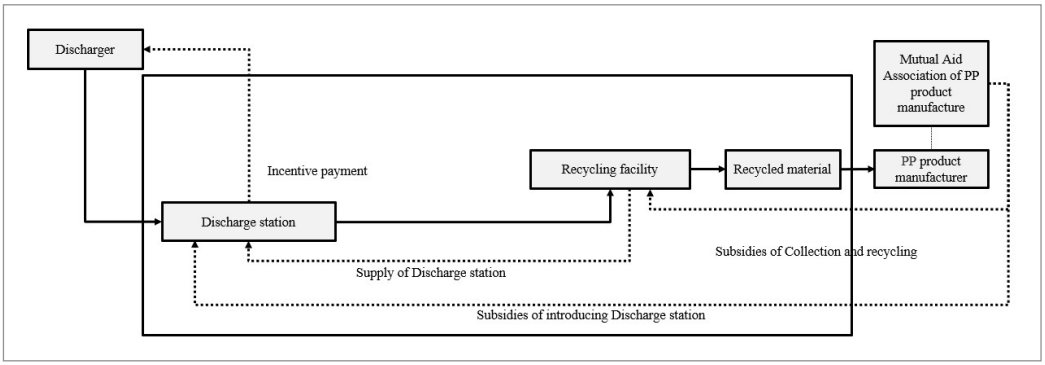
Large-scale discharge sources were classified into PP product manufacturers and electrical and electronic waste vehicle recycling companies. Manufacturers of PP products are encouraged to recycle themselves as much as possible, but if there is no reduction facility, it is designed to be recycled by an external recycling company. Wastes generated by recycling companies were sorted using specialized sorting facilities and then consigned to recycling facilities for separate dischargers.

<Figure 5-8> PP discharge and recovery model of Ecuador



Looking at the business model of separate discharge and recovery of PP, the recycling company is at the center, and is in charge of both the installation and management of the station discharge site and the collection and recycling of recyclables. However, since there will be a lot of cost in establishing the initial recovery and recycling system, a cooperative is established by the EPR system, and the cost of establishing a station discharge and recovery and recycling subsidies are paid. Resource recycling shops and stations should be used for the separation and discharge bases. However, it is necessary to introduce ACI's ITainer and resource recycling shops for densely populated areas and disseminate entry-level recycling stations for low densely populated areas.

<Figure 5-9> PP business model of Ecuador



<Figure 5-10> Required technology to build a PP recycling model (Station discharge)

Resource recycling shop (house and multi-family house, general business place, island, and mountainous area)	Recycling station (Apartment)
	
Recycling station entry-level (Other areas)	Natural shops (Concentrated areas)
	

When collecting waste, it is necessary to adopt a day-of-the-week collection model and proceed with efficient collection. Generally, collection days and items are determined mainly for items convenient for residents to separate and have a good recycling effect among recycled items. Below, similar to Korea, Ecuador's daily discharge and collection methods are proposed.

[Table 5-8] Ecuador daily collection method (plan)

Monday Wednesday Friday	Tuesday and Thursday
• General plastic • Boxes, papers • Cans, glass bottles	• Transparent plastic bottle • Waste vinyl

<Figure 5-11> Required technology for building PP recycling model (collection vehicle)

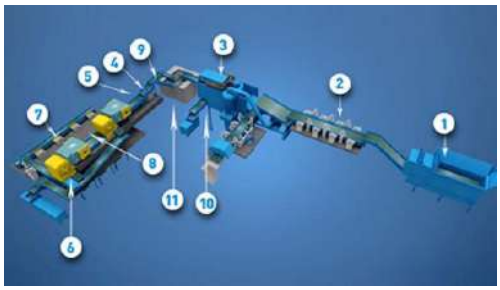
Collection vehicle by item (Waste papers, eps, films, transparent plastic bottles, etc.)	mixed collection vehicle (Containers, scrap iron)
	

The collected recyclables are transferred to a recycling sorting facility. The proposed sorting facility is ACI's recycling sorting facility, consisting of a crusher, a ballistic sorter, and an optical sorter. Particularly, the automatic optical sorter is effective in sorting colored and transparent PET (PET), polyethylene (PE), polystyrene (PS), and polypropylene (PP) after detecting the plastic material and color by analyzing near-infrared and visible light. However, in Korea's experience, small plastic wastes, such as disposable coffee cups and straws, are often thrown away due to their limited processing capacity, and these discarded plastics are incinerated. Therefore, to increase the recycling rate of waste PP, a system capable of regulating plastic materials and facilities for recycling contaminated or small PP is required.

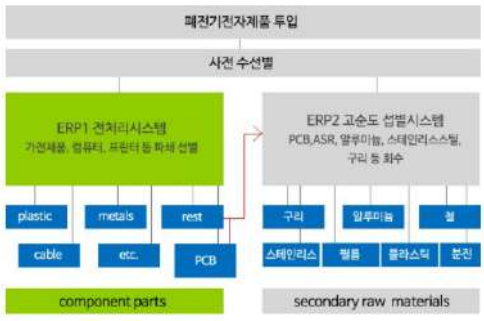
ACI's WEEE/ASR can recycle PP from electronic waste products or scrap cars. In this facility, ACI and Germany's UMS (Urban Mining Solutions GmbH), in partnership, are supplying recycling facilities and systems that sort metal and plastics by recycling waste electrical and electronic products and vehicles. The overall system configuration is divided into pre-treatment and high-purity sorting systems. The predisposal system consists of manually disassembling and shredding various electrical and electronic wastes in advance. The main equipment is a rotary chain crusher (RCC), which exerts a strong impact with an elastic rotating chain and cuts the input between the wall and the chain to an appropriate size. It crushes and can be configured either continuously or batch-wise. The crushed material discharged from the rotary crusher (RCC) is transferred to the next process without

dust by a vacuum suction machine. Afterward, most of the large-scale hardware is sorted using a strong magnetic sorting machine. Additionally, small crushed materials are sorted using a drum, a special particle size separator, and plastics, non-ferrous metals, and ferrous metals are sorted by magnetic separators, non-ferrous sorters, and automatic optical sorters for products with a size of 8 mm or larger.

<Figure 5-12> Required technology to build a PP recycling model (sorting facility)

ACI recycling sorting facility	Breaking machine
	
Ballistic sorting machine	Optical sorter
	

<Figure 5-13> Required technology to build a PP recycling model (sorting facility-waste electrical and electronic products/waste vehicle sorting facility)

ACI (WEEE/ASR)	Outline
	

[Table 5-9] Contents and benefits of the discharge and recovery

Contents		Benefit
Discharge Station		• The cost of collection can be minimized
Use of collection vehicles by item		• Prevention of mixing by item between collections
Management focused on massive-sources		• Getting quantity for commercialization of recycling
EPS	• Install a reduction device generating sources	• The cost of collection can be minimized ** Usually using a fixed reducer, by situation, use Mobile and chemical reducers*
PP	• Supply of separate discharge sites	• Easy recovery by material ** CCTV should be installed to monitor separate discharge (due to low awareness)*
	• Introduction of sorting facility	• Collected waste can be used to the maximum
	• Introduction of PP recycling facilities from automobiles and electronic industry	• Getting a place to recycle materials for PP

1.2.3 Recycling

After the waste is recycled, its use as a raw material should be encouraged. In Korea, as the need for measures to reduce the use of single-use plastics and promote the recycling of plastics emerged as the increase in plastic waste and instability in the recycling market intensified after COVID-19, the scope of regulations for single-use products was expanded as well as the use of recycled materials.

Preparing a range that can be recognized as a recycled material is necessary. The recycled materials for EPS were classified into crushed and compressed products, ingots, and pellets by stage, and PP was limited to flakes and pellets. As the classification of recycled materials becomes clear, standardized quality standards can be established.

[Table 5-10] Classification of EPS and PP recycled materials

EPS			PP	
Crushed and compressed products	Ingot	Pellet	Flake	Pellet
				

In Korea, a recycling resource information center is being operated to promote the use of recycled materials and products.

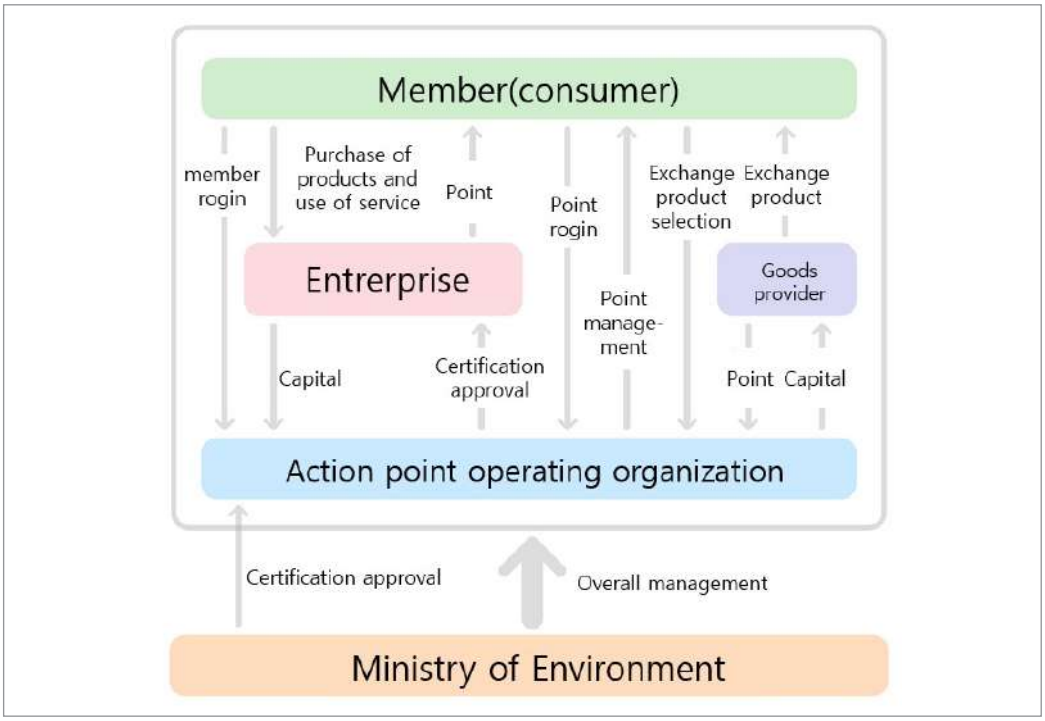
Resources like waste resources that share distribution information, such as waste, recycled resources, and recycled products, support related businesses by distribution support, electronic bidding, and circulation marketplaces. It is a circular comprehensive information system.

It contributes to fostering the recycling market and enhancing the competitiveness of related industries by improving the profit structure by increasing the amount of waste traded, reducing disposal costs, and forming a resource circulation network between suppliers and consumers of waste and waste resources.

- Operation of on-site distribution support service for optimal disposal of waste resources
- Provide user-tailored resource circulation information (recycling method/price, policy technology trends, etc.)
- Provide information on the demand and supply of waste and circulating resources, such as electronic bidding and electronic water service
- Spreading a resource circulation culture by a campaign to activate the recycling resource information center

To promote the use of recycled materials, it would be reasonable to utilize Korea's Green Product Purchase Act, the obligatory use of recycled materials, and Japan's Eco Action Project. The Green Product Purchase Act can promote the purchase of recycled products in the public sector, such as in local government offices. However, Korea's Green Product Purchase Act restricts green products from recycled products because it is difficult to innovatively increase the demand for them. Japan's eco-action point system is a system where eco-action points are operated by participating companies and organizations (private companies, local governments, and other fund providers), and consumers can purchase goods and services to countermeasure against global warming or take actions to conserve energy. It is a system that induces specific actions by giving incentives. No matter how great a product or service is, it is difficult to penetrate the market without credibility and brand power. In the package-to-package market, it is difficult to convey the advantages of products and services to each customer. Unlike Korea's eco-mileage system, financial resources are borne by the manufacturer, so it will be suitable as a model for inducing sustainable, eco-friendly consumption. However, to implement the eco-action point system, it is necessary to prepare a system fee, point specifications, and a place to use the points.

<Figure 5-14> Overview of the Japan Eco Action Point Project



[Table 5-11] Contents and benefits at the recycling stage

Contents	Benefit
Introduction of the waste treatment business permit system	• Waste statistics can be established by the permitter's reporting system ** It is possible to identify the amount of recycled materials by the permit system*
Establishment of a distribution center for recycled materials and products	• Support for distribution of recycled materials and products
EPR contribution and wastes charge reduction of companies when using recycled materials	• Promote the use of recycled materials
Establishment of the Recycled product Obligatory Purchase Act	Promote consumption of recycled products in the public sector
Introduction of Eco Action Point System	Promote consumption of recycled products in the private sector

2. Roadmap for establishing a resource circulation model for Ecuadorian EPS and PP

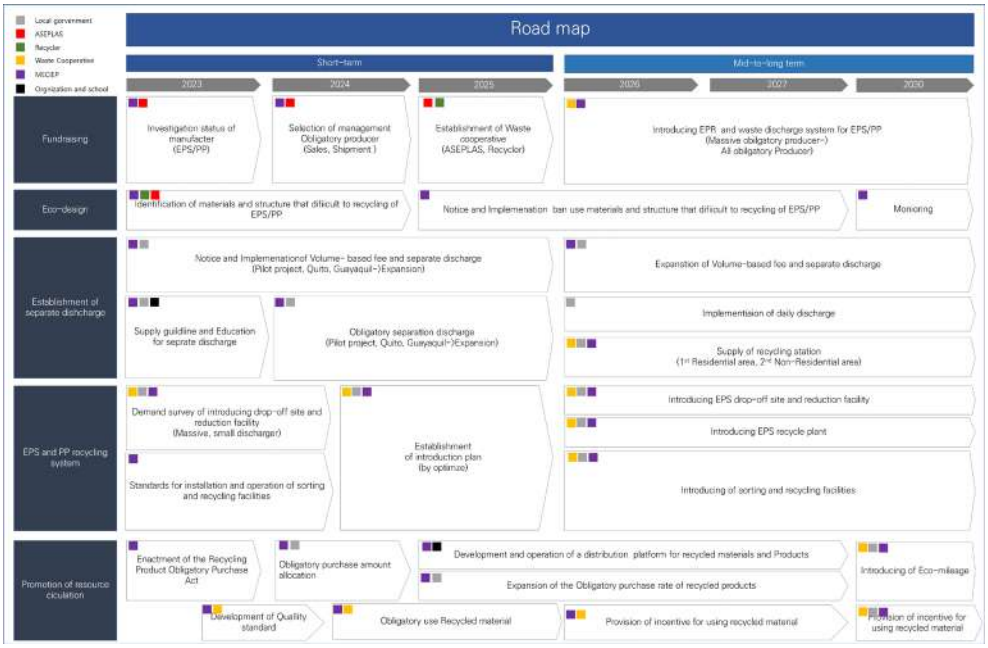
2.1. Overview roadmap

A roadmap was presented to strengthen Ecuador's EPS and PP recycling industry. Benchmarking promotion contents were set to establish an eco-friendly design base for easy recycling, a separate discharge base for recovery, and a recycling system for resource circulation.

[Table 5-12] Contents and benefits at the recycling stage

Goal	Reinforcement of competitiveness in the recycling industry of Ecuador's resource recycling type EPS and PP	
Target	• Establishment of an eco-friendly design foundation - Establishment of a separate discharge basis - Establishment of the recycling system	
Contents	- Introduction of VBR, EPR and waste discharge system	Fundraising
	- Introduction of regulations on the material structure of packaging materials	Eco-design
	- Preparation of guidelines for separate discharge system - Implementation of education on separate discharge and promotion, development of applications, and Obligatory separation of discharge - Introduction of the recycling station	Establishment of separate discharge
	- Introduction of mass discharger reduction equipment - Introduction of EPS recycling facility	Establishment of the EPS recycling system
	- Establishment of standards for installation and operation of sorting and recycling facilities - Introduction of sorting and recycling facilities	Establishment of PP recycling system
	- Development of quality standards for recycled materials - Obligatory use of recycled materials - Promotion of green consumption	Promotion of resource circulation

Roadmap



2.2 Activity and strategy

(1) Fundraising

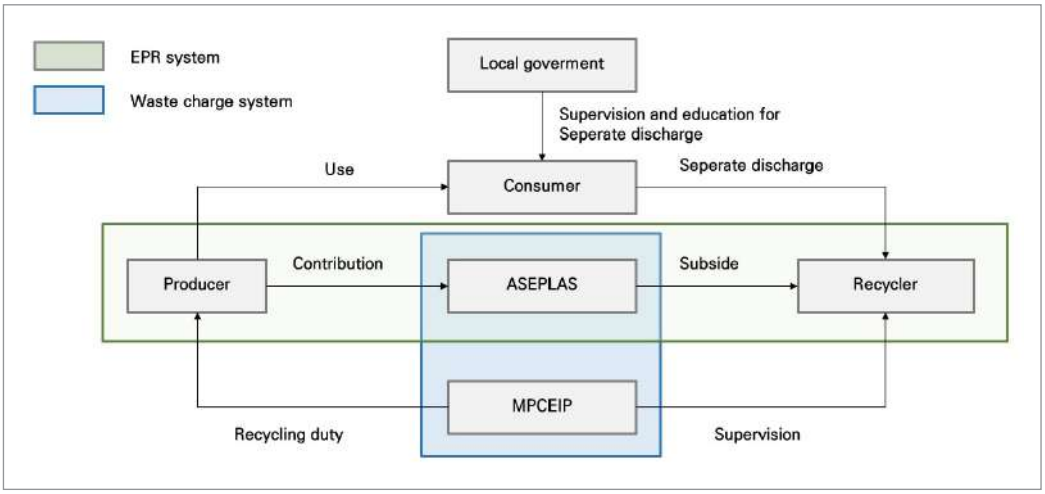
① **Introduction of EPR and Waste discharge system**

a) Contents

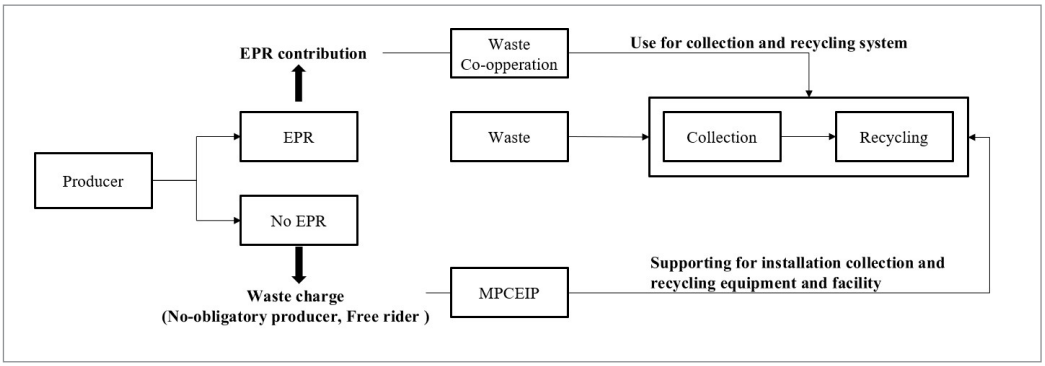
The EPR and Waste discharge system will be introduced for all producers who use EPS and PP materials, home appliances, and electrical and electronic products.

Establish and operate cooperatives for EPS and PP obligatory producers. The cooperative was proposed as ASEPLAS. MPCEIP assumes the role of the Ministry of Environment. It can be operated in the following structure.

<Figure 5-15> EPR and Waste discharge system introduction system diagram



<Figure 5-16> Operation of EPR and Waste discharge system



[Table 5-13] Role of each stakeholder in EPR introduction in Ecuador

Stakeholders	Role
Consumer	• separate discharge
Recycling Obligation Producer	• Fulfillment of collection and recycling obligations
ASEPLAS	• Contribution management for the joint ful fillment of recycling obligations
Local government	• Establishment of a separate discharge basis

Stakeholders	Role
MPCEIP	• Receipt and approval of the obligation fulfillment plan of recovery/recycling • Receipt of performance report on the fulfillment of collection and recycling obligations and confirmation of performance • Matters related to the implementation of the system, such as the imposition of recycling charges • Confirmation and investigation of recycling sites • Overall system operation, such as enactment and revision of laws and regulations • Announcement of calculation of recycling duty rate by item yearly • Approval of establishment of recycling business cooperative and support and management of local governments and Korea Environment Corporation • Mediation and resolution of conflicts between actors

b) Process

[Table 5-14] Guide for introducing EPR and waste discharge system

STEP	Contents	Period
1	Investigation status of the manufacturer (EPS/PP) ** Sales/Import, Product, Usage of EPS, PP*	`23
2	Selection of management producer ** Massive dischargers are managed with the EPR, and those below are managed with a waste charge system.*	`24
3	Establishment of waste co-operative (ASEPLAS, Recycler) ** Calculation of EPR contribution and waste discharge*	`25
4	Implement EPR and waste discharge system for EPS/PP (Massive Producer), Expended EPR and waste discharge system for EPS/PP (All Producer)	`26~

(2) Eco-design

② **Packaging material structure regulation system**

a) Contents

It is necessary to design EPSs and PPs to be easily recycled to get economic feasibility for recycling companies. The materials and structures of packaging materials in Korea are as follows.

[Table 5-15 | Packaging material and structure in Korean

division		Material/structure for easy recycling		Materials and structures that are difficult to recycle
EPS	Body	White single material		When it is impossible to separate foamed plastic from other materials as it is a composite material structure (including combination with other materials) Colors other than white (black EPE, EPP material is normal grade)
	Labels, caps, and miscellaneous materials	In case of any of the following: - Unused - The same material as the body		Directly printed on the body When it is impossible to separate from the body as it is a different material from the body PVC-based material
Plastic single material container, tray packaging material	Body	Single material (PET material is limited to colorless)		When glycol-modified PET resin (PET-G) material is mixed colored PET material PVC-based material
	Labels, closures, and miscellaneous goods	PET material	In case of any of the following: - Unused - Non-adhesive ※ *It is recommended not to use adhesive or direct printing.*	PVC-based material
		Materials other than PET	In case of any of the following: - Unused - Directly printed on the body - The same material as the body - When it is possible to separate the body from the body as it is made of a plastic material different from that of the body	PVC-based material When a straw is attached while using a lid or a stopper that contains a material other than plastic In case the body is of a different material and cannot be separated from the body

b) Process

[Table 5-16] Guide for introducing the packaging material structure regulation system

STEP	Contents	Period
1	Identification of materials and structures that make recycling of difficult ** There is no problem using Korean standards, but it can be modified to suit local Ecuador.*	`23–`24
2	Notice and implementation of ban on the use of materials and structures that make recycling difficult ** Notice `24–`25, Implementation by Step by Step (Reduce > Replace > Ban)*	`25–`27
3	Monitoring ** Investigation of products using materials and structures that are difficult to recycle by periodic market research and fine*	Continuous

(3) Establishment of Separate discharge

① Obligatory separate discharge and labeling systems

a) Contents

There is a need to prepare a legal basis to make Ecuador's separate discharge obligatory. In this way, legal obligations can be given to local governments and citizens. However, since a large amount of capital is required to establish a separate discharge system, the necessary financial resources must be created so that the necessary financial resources can be get by a business model with the government (waste charge and EPR system) and private companies.

1. Local governments should establish a separate discharge system.
2. Citizens must separate and dispose of recyclable resources, and non-compliance may result in a fine of not more than $X for negligence.
3. Local governments can receive support from the government for the cost of establishing a separate discharge system.

The system for labeling the separate discharge of the emitter is as follows. Based on this, the obligatory producer should mark the separate discharge pattern. The standards and methods of separate discharge labeling are as follows.

[Table 5-17] Separate Labeling method

Category	Contents
Reference date	• Date of manufacture of the product
Marking method	• Printing, engraving, or labeling
Mark size	• At least 8 mm in width and height (excluding text on display material)
Mark color	• Colors that contrast with the overall color of the product/packaging subject to display -When printing in color, it is recommended to use the same color as the container for separate collection for each item as stipulated in Article 6 (2) of the「Guidelines for the Separate Collection of Recyclable Resources, etc.」(Ordinance of the Ministry of Environment)
Mark position	• The front, side, or bar code top, bottom, left, and right of the product/packaging material -If it is impossible to display the front, side, or up, down, left, and right of the barcode due to its shape or structure, it can be displayed on the bottom or the lid
Multiple packaging	• Mark each separate part or packaging material -In cases where it is difficult to separate discharge labeling for multiple packaging materials that cannot be separated and individual packaging materials due to material and structure, it is possible to collectively indicate in one major part.

Category	Contents
Imported products	• If multiple inner packaging materials are of the same material inside the outer packaging material, the material can be marked as one.
	• In the case of cosmetics imported in outer packaging, separate discharge labeling is possible along with the container, etc., according to the provisions of Article 10 of the Cosmetics Act.
Label-free plastic bottle	① In the case of not using a label on the container or ② using a label with a bottle cap, the separate discharge indication can be displayed on the outer surface of the small wrapping paper or the carrying handle attached to the outer surface of the wrapping paper.
Eat spring water	• Mark in an easily identifiable location and in an indelible way

The guidelines for separate discharge of EPS and PP are as follows.

[Table 5-18] Separate collection items and discharge guidelines when disposing of recyclable resources by item

Item		Discharge guidelines
Plastic containers and trays	Containers and trays made of PVC, PE, PP, PS, and PSP materials	- Remove external material, such as emptying the contents and rinsing with water, before discharging ※ *Containers that cannot be rinsed with water (toothpaste containers, etc.) are discharged after emptying the contents.* - emove the body and other materials, such as attached trademarks and accessories, before discharging - In the case of a pumping container, remove the pump with an internal steel spring and discharge it. ※ *Examples of applicable items: beverage containers, cleaning containers, etc.* ※ *Non-compliant items: Toys and stationeries with materials other than plastic attached, clothes hangers, toothbrushes, file files, telephones, fishing rods, strollers/walkers, CDs/DVDs, travel trunks, golf bags, etc. Discharge in accordance with local government ordinances, such as waste disposal*
EPS	EPS buffer material	- Remove external material , such as emptying the contents and rinsing with water, before discharging - Remove EPS and other materials, such as attached trademarks, before discharging - When purchasing electronic products, such as TVs, the foamed plastic packaging material used as a buffer material should be returned to the place of purchase as much as possible. ※ *Applicable items: foamed styrene box for packaging agricultural, fishery, and livestock products, foamed plastic packaging material used as a buffer material for electronic products* ※ *Non-compliant items: EPS coated or bonded with other materials, EPS for interior/exterior materials for construction, food stains or foreign substances that are difficult to remove, etc., are discharged in accordance with local government ordinances, such as volume-based bags, special size sacks, or large-scale waste disposal.*

In Korea, recycling station is approximately 100–150 households or one place per 100–150 m is installed and operated. The installation site is flexibly selected considering local conditions, and this has no separate standard. In Korea, when introducing a recycling

station, it was difficult to select a location, and as a solution, a semi-wide recycling station was introduced.

Recycling stations are generally configured to dispose of all domestic waste. The volume-based fee system allows only combustible and non-combustible waste to be input. Recyclables consisted of cans/scrap metal, papers, plastic containers, vinyl, glass bottles, PET bottles, and EPS. Considering that Ecuador separates waste into organic and non-organic types, it is thought that it will be advantageous for the system to be established early if it is expanded to 6 items after the separate collection culture is established. This is because the emitter needs to be familiar with and adapt to separate discharge.

Volume-based fee system is possible to reduce the amount of waste generated, get the amount of recycling, change the public's consciousness, and promote the development of recycling treatment technology. However, since currently imposes a waste tax on various fees(Electricity, water and sewage, property, waste), there is a problem that the collection fee system needs to be completely reorganized when the volume-based fee system is introduced. This is because the fee rate is determined by reflecting financial conditions and citizens' willingness to accept them. Therefore, the fee should be implemented lower than the current one, but should be introduced in the direction of gradually increasing it when it is settled to some extent.

[Table 5-19] Recycling Station Waste Classification System

Volume based fee	Recyclable resources	Food waste
(Transparent) Combustible waste	(Yellow) Cans/Scrap metal/Glass bottles	• RFID (Radio Frequency Identification)
	(orange) Paper	
	(blue) Plastic containers	
(Green) Non-combustible waste	(black) Vinyl	
	(red) PET bottle	
	EPS	

[Table 5-20] Recommended recycling station

recycling station	recycling station (Clean house)
	
- (Overview) Dispose of recyclables in the installed collection box - (Operation period) Anytime - (Installation/Operating entity) Recycling company • (Installation place) All places • (Cost) about 500,000 won	- (Overview) Dispose of recyclables in the installed collection box - (Operation period) Anytime - (Installation/Operating entity) Recycling company • (Installation place) All places - (Manufacturer) Union City Co., Ltd. • (Cost) about 10 million won

As a semi-wide recycling station, you can consider using a resource recycling shop or a natural shop (ITainer-R).

[Table 5-21] Recommended semi-wide recycling station

Resource recycling shop	ITainer-R
	
- (Ov w) If you bring recyclables to a resource recycling shop, they will be refunded as mileage that can be used in the area. - (Operating period) Operates every Tuesday and Saturday - (Installation/Operating entity) Recycling company • (Installation place) Residential area	- (Overview) When recycled materials are put in, the fee is refunded based on this. - (Operation period) Anytime - (Installation/Operating entity) Recycling company • (Installation place) Commercial area - (Manufacturer) ACI

The recycling station in Ecuador first identifies and maps the point where a large amount of waste is being discharged. Then, pilot projects should be performed in various forms, such as recycling and semi-regional recycling stations. The roadmap for introducing recycling

stations and semi-wide recycling stations is as follows.

If the total population of each region is divided by four, the total number of households is 2,684,949 households, and the required number of recycling stations (150 households/vehicle) is calculated to be 17,900. Considering the installation cost of 500,000 won per station, it costs about 7,397,553 USD. If it is installed as a recycled neighborhood yard (300 households/unit), 8,950 households, and the installation cost is 10 million won, it costs about 73,965,530 USD.

[Table 5-22] Cost of introducing the recycling station

State	Number of Households (Generation)	Recycling station		Recycling station(Clean house)	
		Number of points	Cost required (USD)	Number of points	Cost required (USD)
Ambato	94,631	631	260,691	315	2,606,908
Riobamba	64,649	431	178,097	215	1,780,971
Guarnada	26,597	177	73,269	89	732,693
Latacunga	50,024	333	137,806	167	1,378,058
Quevedo	51,766	345	142,606	173	1,426,061
Babahoyo	43,126	288	118,803	144	1,188,030
Tulcan	25,014	167	68,910	83	689,098
Lago Agrio	28,626	191	78,859	95	788,588
Santa Elena	47,624	317	131,194	159	1,311,942
La Libertad	27,607	184	76,051	92	760,510
Machala	70,759	472	194,929	236	1,949,291
Loja	65,975	440	181,749	220	1,817,493
Cuenca	153,635	1,024	423,236	512	4,232,362
Sto.Domingo	110,697	738	304,950	369	3,049,504
Quito	672,538	4,484	1,852,720	2,242	18,527,204
Ruminahui	27,452	183	75,625	92	756,247
Cayambe	25,975	173	71,556	87	715,558
Mejia	25,783	172	71,028	86	710,275
Portoviejo	79,111	527	217,937	264	2,179,366
Manta	64,763	432	178,410	216	1,784,105
Jipijapa	18,699	125	51,513	62	515,131

State	Number of Households (Generation)	Recycling station		Recycling station(Clean house)	
		Number of points	Cost required (USD)	Number of points	Cost required (USD)
Guayaquil	667,950	4,453	1,840,083	2,227	18,400,833
Duran	75,122	501	206,948	250	2,069,477
Milagro	48,656	324	134,037	162	1,340,372
Daule	40,684	271	112,076	136	1,120,758
Samborondon	23,746	158	65,415	79	654,153
Esmeraldas	53,744	358	148,054	179	1,480,544
Sum	2,684,949	17,900	7,396,553	8,950	73,965,530

source: CARTOGRAFÍA, de los residuos sólidos en Ecuador, 2020

b) Process

[Table 5-23] Guide for obligatory separate discharge and labeling system

STEP	Contents	Period
1	Notice of Implementation of a volume-based fee system and obligatory separate discharge * Determination of unit price and specifications	`23–`25
2	Implementation of a volume-based fee system and obligatory separate discharge * Pilot project, Quito, Guayaquil	`24–`25
3	Supply guidelines and education advertising for separate discharge	`23–`25
4	Expansion of a volume-based fee system and obligatory Separate discharge	`23–`25
5	Supply of recycling station	`26~
6	implementation of daily Discharge	`26~

(4) EPS and PP recycling system

① **Introduction of mass-discharge EPS reduction equipment**

a) Contents

To introduce a reduction equipment for mass-discharge sources, its installation must be made obligatory, and the legal provisions are as follows.

1. A business operator that discharges industrial wastes shall minimize the generation of industrial wastes by installing waste reduction facilities, etc.
2. The government and local governments can support business operators when they want to reduce waste by installing waste reduction facilities.

The mass discharger, subject to the obligatory installation of the reduction equipment, targets the wholesale markets for agricultural and fishery products, department stores, large marts, and home appliance dealers. ASEPLAS, a cooperative, pays subsidies for the installation of reduction equipment at large dischargers, and recyclers sell and lease the reduction equipment to large dischargers. The mobile reduction unit supplier handles the construction site offshore for a fee. The recycler purchases the reduced EPS from the reducer to compensate for the cost of installing the reducer, and the collected EPS is manufactured from recycled materials and sold to the obligatory producer.

The introduction of reduction equipment for the mass-discharge EPS is as follows. In the initial stage, it is necessary to identify the target for mass-discharge source management. A notice mandating the installation of a reduction equipment for each mass-discharge source and the installation facility is issued. Due to the obligatory mass discharger, interest in installing mass dischargers will increase, and an incentive to pay a subsidy for installing a mass discharger will be given to investigate the business demand. Then, ASEPLAS and recyclers should establish a plan to distribute the reduction equipment considering the demand and budget for the recycling levy and conduct annual dissemination. Ecuador's mass-discharge sources are estimated to be 1,427, so 30,325,360–70,760,331 USD of financial resources is required.

[Table 5-24] Estimated cost of installing a reduction equipment according to mass generation sources in Ecuador

Category		Number	Reducer installation cost(USD)	
			Dain Machine (mechanical)	Tipple (chemical)
Agricultural and Fishery Market		234		
Large Retail Store	Supermarket	396		
	Department	68		
	Other large stores	N/A		
Plastic product manufacturing		600		
Home appliance store		129		
Required number of reducers		1,427	30,325,360	70,760,331

(i) Introduction of EPS and PP recycling facility

Optimized areas between neighboring city areas for each major city in Ecuador were calculated. In the case of individual installation, 27 places should be installed, but in the case of optimization, it can be installed in 12 places. A total of 20 facilities must be installed as well as a financial resource of 49,586,777 USD.

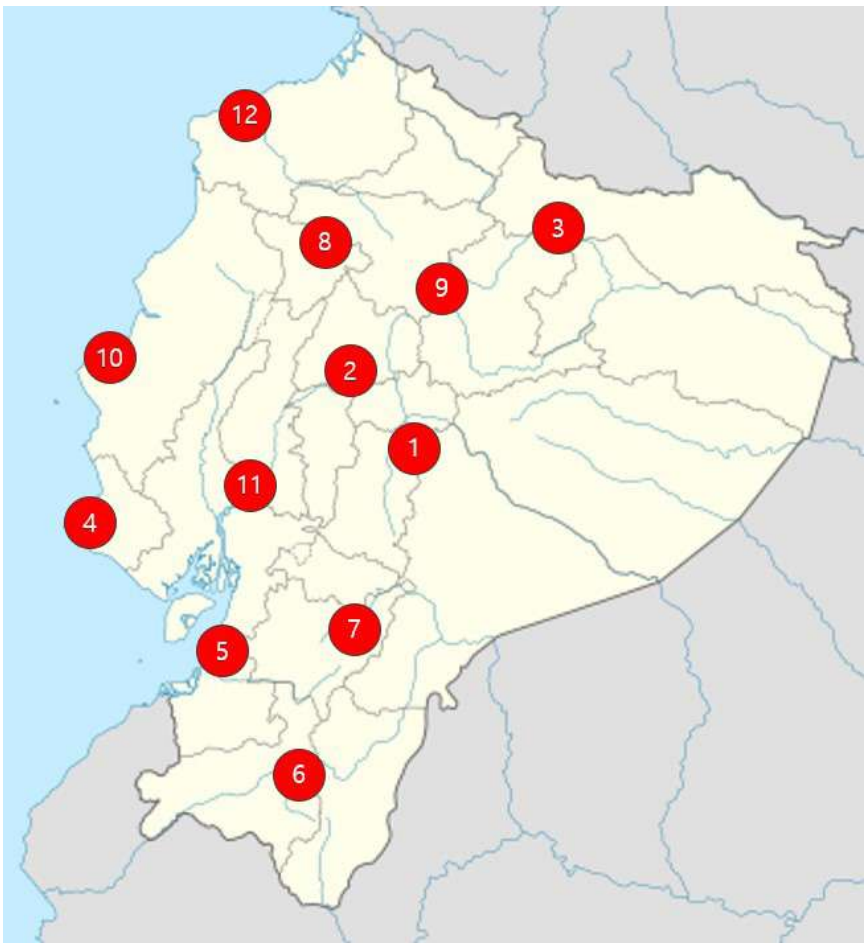
[Table 5-25] Review of the optimization area

Province	State	Population Total	Density of Population (hab./km2)	Waste (ton/day)	Optimization area
Tungurahua	Ambato	378,523	3,840	235	1
Chimborazo	Riobamba	258,597	2,654	155	
Bolivar	Guarnada	106,387	107	83	
cotopaxi	Latacunga	200,094	371	84	2
Los rios	Quevedo	207,064	830	269	
Los rios	Babahoyo	172,502	555	117	
Carchi	Tulcan	100,057	435	75	3
Sucumbios	Lago Agrio	114,503	152	85	
Santa Elena	Santa Elena	190,494	99	101	4
Santa Elena	La Libertad	110,426	1,117	74	
El Oro	Machala	283,037	1,167	283	5
Loja	Loja	263,900	632	182	6
Azuay	Cuenca	614,539	4,702	332	7
Sto.Domingo	Sto.Domingo	442,788	280	359	8
Phchincha	Quito	2,690,150	4,348	2,367	9
Phchincha	Ruminahui	109,807	1,416	86	
Phchincha	Cayambe	103,899	133	78	
Phchincha	Mejia	103,132	59	76	
Manabi	Portoviejo	316,444	534	158	10
Manabi	Manta	259,052	1,046	194	
Manabi	Jipijapa	74,797	123	135	

Province	State	Population Total	Density of Population (hab./km2)	Waste (ton/day)	Optimization area
Guayas	Guayaquil	2,671,801	919	3,420	11
Guayas	Duran	300,488	785	213	
Guayas	Milagro	194,622	658	158	
Guayas	Daule	162,734	468	81	
Guayas	Samborondon	94,983	224	85	
Esmeraldas	Esmeraldas	214,975	2,298	144	12

source: CARTOGRAFÍA, de los residuos sólidos en Ecuador, 2020

<Figure 5-17> Optimization area in Ecuador



[Table 5-26] Cost of introducing EPS recycling facility in Ecuador

No	EPS (t/year)	Number of Recycling Plants Required	USD
1	932	1	2,479,339
2	726	1	2,479,339
3	269	1	2,479,339
4	377	1	2,479,339
5	355	1	2,479,339
6	331	1	2,479,339
7	770	1	2,479,339
8	555	1	2,479,339
9	3767	5	12,396,694
10	815	1	2,479,339
11	4291	5	12,396,694
12	269	1	2,479,339
Sum	13,457	20	49,586,777

A plant to recycle the products currently being discharged should be installed. The recycling plant should be installed and operated by the weight reducer manufacturer. In Korea, a subsidy is provided for a type of recycling infrastructure installation. The financial resources are utilized from environmental taxes, such as the waste and recycling levies. Therefore, it would be desirable for selective recycling facilities to support recycling levies got by ASEPLAS to recycling companies.

In Korea, local governments are responsible for installing and operating recycling sorting facilities. For this reason, in most cases, sorting facilities are installed and operated by local governments. Some local governments use wide-area sorting facilities or entrust the operations to the private sector. However, since Ecuador promotes the supply of private-led wide-area recycling facilities, more efficient operation is possible than in Korea. This is because the environmental, economical, and technological characteristics of waste disposal can be improved by an integrated management of wastes within the optimization region beyond the boundaries of administrative districts.

Optimized areas between neighboring cities for each major city in Ecuador were calculated. In the case of individual installation, 27 places should be installed, but in the case of optimization, it can be installed in 12 places. For the total project cost, the Korean automatic sorting facility installation cost is applied, and if 1210 won/1 USD is applied,

approximately 870 million USD is required.

However, considering the current situation of partner countries, manual sorting seems to be more economical and realistic than optical sorting. In addition, the initial investment cost is low and the employment effect is large. Even though 20 years have passed since the introduction of the EPR system in 2003, Korea still relies on repair and sorting. Local municipal public sorting facilities are small in scale and lack of space, so repair sorting is the mainstay. Therefore, if the budget is insufficient in Ecuador and the economic feasibility of treatment is insufficient, the water sorting facility will be introduced first, but the strategy of introducing the optical sorting facility in the future may also be considered.

[Table 5-27] Cost of introducing a sorting and recycling facility in Ecuador

No	Recyclable material amount(t/year)	Sorting facility installation cost
		USD
1	203	43,350,951
2	202	43,140,073
3	69	15,216,442
4	75	16,379,357
5	122	25,950,791
6	78	17,018,643
7	143	19,190,083
8	154	32,884,083
9	1,121	239,045,444
10	209	44,663,894
11	1,701	362,782,969
12	62	13,717,370
Sum		873,340,100

b) Process

[Table 5-28] Guide for Introduction of EPS and PP recycling facility

STEP	Contents	Period
1	- Demand survey of introducing trop-off site and reduction equipment - Standard for installation and operation of sorting and recycling facility	`23–`24
2	- Establishment of introduction plan(By optimize)	`24–`25
3	- Introducing EPS drop-off site and reduction equipment ** Pilot project → Realizing Project*	`23–`25
4	- Introducing Sorting(Manual or Automatic) and recycling facility ** Pilot project → Realizing Project*	`25–`30
5	- Introducing EPS recycling facility ** Pilot project → Realizing Project*	`25–`30

(5) Promotion of resource circulation

① Promotion of green consumption

a) Contents

To recycle resources, it is necessary to increase the competitiveness of recycled products. In Korea, the green product system promotes the consumption of recycled products. Additionally, the private sector is giving points to the eco-money system. However, since green products include products with various certifications and recycled products, the effect of promoting the consumption of recycled products is not high. The point of eco-money is that it is difficult to see it as a sustainable method with a public budget.

Therefore, Ecuador needs a system specializing in the sustainable consumption of recycled products. To this end, the public sector should propose a preferential purchase system for recycled products, and the private sector should introduce a green card system.

It is necessary to establish an online environmental information center that shares recycling and distribution information and provides supply and demand information, such as electronic bidding, so that the circulating resources of waste can be valuably used. It should be made available to all waste discharge, transport, and disposal (recycling) facilities and the public. The following information should be provided.

The target of the distribution support service is waste, recyclable resources, and recycled

products. By this, the emitter can save on waste disposal costs, and the recyclers can build a stakeholder platform where they can purchase raw materials at a constant and low cost.

[Table 5-29] Service contents of the online environmental information center

Category	Service
Company information	Waste discharger ② Collection/transport company: Information on waste collection/transport permit companies ③ Recycling/disposal company: Information on recycling and disposal business licensed company ④ Waste disposal facility: Waste disposal facility approval and reporting facility information
circulation information	① Recycling market trend: market analysis, issue analysis ② Recycling price: Monthly price information for recyclable resources ③ Recycling method: Recycling method of major items ⑤ Best practices for recycling: Best practices for recycling

b) Process

[Table 5-30] Guide for the promotion of green consumption

STEP	Contents	Period
1	Enactment of the recycled product obligatory purchase Act ** Local governments make it compulsory to purchase recycled products in proportion to the amount of waste generated*	`23–`24
2	Allocation obligatory purchase of recycled product	`24
3	Development and operation of a distribution platform for recycled materials and products	`25~
4	Expansion of obligatory purchase rate of recycled products	`25~
5	Introducing eco-mileage system	`28~

② Introduction of quality standards for recycled materials

a) Contents

Ecuador's quality standards for recycled materials are to promote resource circulation rather than high value-added recycling and should be for domestic distribution. Additionally, it is necessary to preserve the autonomy of the management of private companies.

Therefore, in the beginning, it should be kept to a minimum within the range where there is no effect on the function or environment of the product. A plan should be secured to apply the quality standard according to the industrial demand for the rest. It seems reasonable to set only foreign substances and pollution standards as recycled materials and check the product's harmfulness by the final product.

The quality standards of recycled materials should be prepared by the Ecuadorian National Standards Agency (INEN) and ASEPLAS. It was suggested that ASEPLAS, a plastics industry association, be the institution for quality inspection and management of recycled materials.

However, for Ecuador to have a competitive edge in leading the recycled plastics industry, it is necessary to satisfy international quality standards. Therefore, it is necessary to have the capability to manufacture to satisfy the quality standards currently being developed in Korea and China, as described above, and in the EU. A business model is needed to import waste plastics from neighboring countries, such as Colombia and Peru, produce them as recycled materials, and then re-export them.

[Table 5-31] Grade standards for each recycled material (draft)

Grade	Level	Goal
1 Level	Usable level for food contact	Promotion of resource circulation
2 Level (Minimal recycled materials)	Levels that cannot be used for food contact but can be used for other purposes	Use of recycled materials and promote diversification of recycling

b) Process

[Table 5-32] Guide for the introduction of quality standards for recycled materials

STEP	Contents	Period
1	Development of quality standards for recycled materials in Ecuador and collecting stakeholder opinions ** After establishing China's recycled material quality standards as a draft, public hearings were held between ASEPLAS and recycling companies*	`23~`24
2	Classification of Ecuadorian recycled material quality standards ** Differentiation of incentives according to Ecuadorian recycled material quality standards,* ** Priority purchase of recycled materials from high-quality recycled material producers*	`23~`24
3	Introduction of international quality standards ** Promotion of internationalization of Ecuador's waste plastic recycling industry (manufacturing and exporting as recycled raw materials after importing waste plastics)*	`23~`24

③ Obligatory use of recycled materials

a) Contents

The Korean government has expanded the obligation to use recycled materials, which is currently only imposed on manufacturers of paper, iron, and glass, to plastic manufacturers from 2023. Particularly, companies that produce plastic PET will be obligated to use more than 30% of recycled materials by 2023. In 2022, we plan to create a basis for labeling the

percentage of using recycled materials on products or containers. Additionally, the waste and producer responsibility recycling contributions are exempted for products using recycled materials.

In Korea, the obligation to use recycled materials applies to all plastic material manufacturers. There are no specific measures for acknowledging the usage rate obligations for this purpose or administrative measures applied when non-fulfillment is not implemented, so it can be considered that it is still in its infancy. Therefore, it is necessary to prepare an accreditation plan and administrative measures for non-implementation.

Accordingly, the subject of Ecuador's obligatory use of recycled materials is the same as that of Korea, but Ecuador does not have a plastics manufacturing industry. Thus, it is necessary to mandate the use of recycled materials in its products.

It is aimed at 30%, and it is necessary to introduce it in stages for those obligated to use recycled materials. However, since the supply and demand of recycled materials in Ecuador should not be difficult or affect the quality, it should be implemented within a sufficient period so that companies can respond.

Additionally, if the obligatory amount is not met, a penalty of 1.15 to 1.3 times the waste levy or recycling levy will be required depending on the insufficient amount.

b) Process

[Table 5-33] Guide for 0bligatory use of recycled materials

STEP	Contents	Period
1	Notice of Obligatory Use of Recycled Materials ** Recommendation for the use of recycled materials*	`23–`25
2	Obligatory fermentation of recycled materials and reduction of EPR and waste charge ** Obligatory fermentation of recycled materials and reduction of EPR and waste levy shipments*	`26~

2.3 Suggestions for realizing the roadmap

Recognizing the importance of recycling plastics worldwide, technologies and policies for recovery and recycling have been implemented. Ecuador's petrochemical industry is poorly developed, so it is difficult to produce its own plastics. Accordingly, new materials are imported as raw materials for plastic products, or waste plastics are imported and recycled to produce plastic products.

Ecuador has been making continuous effort to recycle plastic, Each material has a cause that makes recycling difficult. EPS is difficult to collection and transport because its bulky. PP is a representative single-use plastic, it is difficult to recover and recycle due to its small size and frequent pollution.

Therefore, it is necessary to publish guidelines related to separate discharge, conduct education in public offices and educational institutions, and establish a culture of separate discharges by obligatory separation and reporting. Additionally, a system for recovering plastics from large sources of EPS and PP as well as households will be needed. To establish a recovery and recycling system for private recovery and recycling companies, the waste charge and EPR systems were implemented, ensuring the economic feasibility of recovery and recycling. Establishing quality standards for recycled raw materials is necessary to establish a stable production and utilization system for raw materials. Additionally, recycle content system, priority purchase of recycled products, and the eco-mileage system should be implemented for products using recycled raw materials to provide incentives for purchasing recycled products and to establish and operate a platform for recycled materials and recycled products to support distribution.

In the private sector, a business model should be considered when establishing a recovery and recycling system for EPS and PP. Since EPS is bulky and requires much cost to recover, installing a reduction equipment focusing on mass-discharge sources and bases is necessary. However, since the cost of the EPS reduction method varies greatly depending on the mechanical and chemical recycling methods, it is necessary to consider the regional characteristics of EPS generation and the demand for each use of recycled materials. PP is a material that can be recycled easily, but there are many disposable products, and its economic efficiency of recycling is low. Therefore, separate and discharge small amounts of sources appropriately, but collect and discharge them. Additionally, to recover disposable products, it is necessary to implement a deposit system focusing on the source of the mass generation of disposable products in cafes and restaurants as well as impose recycling items and duty rates for automobile recycling companies or electrical and electronic product

recycling companies where PP is frequently used. To establish a recycling model for EPS and PP and to get economic feasibility of scale, need the recovery and recycling are together. Private companies have to purchase recycled materials produced by station discharge sites or recycling facilities when sold. By this, it is possible to cover the cost of infrastructure construction for separate discharge base and reduction equipment purchasers, thereby securing the economic feasibility of establishing the recovery system. Alternatively, introduction a recycling infrastructure in a large-scale discharge plant, it is business producing recycled materials can be one way. The recovered plastic-recycled materials were designed as the top-priority recycled materials to be purchased by those eligible for the EPR system and the waste charge system, thus forming an interest in eco-friendly design for producers. The introduction model according to the above roles is shown in the figure below.

The characteristics of the Ecuadorian EPS and PP resource circulation model are that the public sector establishes a basis for separate discharge and distribution of recycled products, and the private sector oversees recovery and recycling. It is a sustainable model that maximizes the profitability of private companies and connects the positions of stakeholders, including local governments, citizens, producers, and recovery and recycling companies.

To build this, implement the roadmap presented above. Although there will be difficulties in raising financial resources, the waste charge and EPR systems will play an important role. Since ASEPLAS plays a very important role as a cooperative of EPS and PP, support and development centered on the relevant institutions will be required.

[Table 5-34] Roles for establishing EPS and PP resource circulation model

stakeholder	role
Government	• Preparation of guidelines for separate discharge system • Separate discharge education and publicity • Development of the separate discharge application • Establishment of regulations on the structure of packaging materials • Introduction of EPR system and waste charge system • Obligatory separation of waste • Preparation of installation and operation standards for sorting recycling facilities • Recycled material quality development • Development and operation of a distribution platform for recycled materials and recycled products • Introduction of Recycled product consumption promotion system and green card • Enhancing environmental awareness by broadcasting media and school education

stakeholder	role
Local government	• Separate discharge education and publicity • Introduction of the recycling station • Introduction of sorting recycling facilities
School	• Resource recycling education • Separate discharge experience and practice
Environmental organizations	• Raising citizens' environmental awareness • Promotion of resident participation
ASEPLAS	• Operate EPR system and waste charge system • Introduction of the recycling station • Recycled material quality development • Development and operation of a distribution platform for recycled materials and recycled products • Introduction of sorting and recycling facilities
Producer	• Obligatory use of recycled materials • Participation in the EPR and waste levy systems
Recovery and recycling business	• Introduction of the recycling station • Introduced EPS mass-discharge source reduction equipment • Introduction of EPS recycling facility • Introduction of sorting recycling facilities • Recycled material quality development
Citizens (consumers)	• Compliance with separate discharge obligations • Green consumption

06

CHAPTER

Linked Project Proposal

1. Project to Introduce the Waste Law
2. Project to Establish Waste Statistics
3. Project of the EPR System Introduction for Packaging Materials
4. Project of Optimization and Area-Wide Waste Disposal Process
5. Project for Introducing a Recycling Station
6. Project of Education for Separate Discharge
7. Project of Regulation of Packaging Material and Structure
8. Project of Standard of Obligatory PCM Use and Development of Quality Standard
9. Project of Installation of Recycling Facility

Linked Project Proposal

A follow-up project means a project to realize the roadmap after the completion of knowledge sharing. The contents proposed in the roadmap can be commercialized and presented as follows.

1. Project to Enactment the law for waste management

For waste management, it is necessary to specify and manage what is waste and to what extent it is waste. Therefore, managing wastes should be clearly defined by coding the legal definitions and type of wastes. For this purpose, the classification system is considered the most reasonable to apply mutatis mutandis, the classification system of the OECD (Organization for Economic Cooperation and Development), which is a global organization and has a waste classification. However, if there is a plastic material or a target waste to be managed intensively in Ecuador, it is necessary to consider a method to subdivide it within the scope of compliance.

Additionally, to manage the flow of waste, it is necessary to code the type of waste treatment and simultaneously ensure that there are no blind spots in the management by the waste treatment business licensing system.

The main contents and implementation plan of the project are as follows.

[Table 6-1] Overview Linked Project (1)

Overview	- Enactment of waste-related laws
Finance	- Treasury
Contents	- Definition of waste, responsibility for disposal, and regulations requiring separate discharge - OECD waste classification system survey and Ecuadorian waste classification system development - Waste treatment type coding (Korea benchmarking) - Introduction of the waste treatment industry licensing system
Advisory	- OECD, KOTRA, Consulting firm in Korea

2. Project to establish waste statistics

It is necessary to establish statistics to properly manage waste. It difficult to establish clear statistics at this stage. However, only by selecting a sample on a national scale to determine the amount of waste generated by region, data necessary for the installation of separate discharge bases and waste treatment facilities can be obtained.

Accordingly, it is necessary to get the amount and composition of household waste by collection and transport companies and establish the amount and composition of industrial waste by a separate electronic handover system. In Korea, the process of waste from discharge to final treatment is transparently managed by the Allbaro system. In Ecuador, there is a need to lay the foundation for efficient waste management by promoting such a waste statistics establishment project.

The main contents and implementation plan of the project are as follows.

[Table 6-2] Overview Linked Project (2)

Overview	- Establishment of statistics for waste management
Participants	- Local governments, waste treatment facilities, waste dischargers/collectors/transporters/processors
Finance	- Treasury, other environmental taxes
Contents	- Calculation of total waste generation and composition by investigation (treatment facility) - Calculation of the amount of waste generated by the establishment of an electronic handover system for workplace waste (discharger/collector/handler) - Ecuadorian waste generation and treatment status statistics
Advisory	- KOTRA and K-eco, consulting firms in Korea

3. Project of introduction of the EPR system for packaging materials and product

It was difficult to activate the recycling of EPS and PP because the economic feasibility of recovery and recycling was low. To solve this problem, it is essential to introduce an EPR system that supports a certain part of the cost of recovery and recycling.

The main contents and implementation plan of the project are as follows.

[Table 6-3] Overview Linked Project (3)

Overview	- Introduction of EPR system for packaging materials
Participants	- government, ASEPLAS, Persons who ship and import more than a certain scale of packaging materials
Finance	- Treasury, other environmental taxes
Contents	- Establishment and investigation of criteria for those subject to Obligatory introduction of EPR - Establishment of EPR operation system, such as the establishment of mutual aid association
Advisory	- KOTRA and K-eco, KPRC, KORA

4. Project of optimization and area-wide waste disposal process

Waste optimization is to reduce social complaints and increase satisfaction by proper waste treatment, improvement of economic efficiency of waste treatment facilities, energy efficiency, and reduction of environmental loads, such as CO2. The promotion method is to achieve wide-area, large-scale, and integration of waste treatment facilities within the provincial areas. To this end, it is necessary to form a management system for the entire process of proper waste treatment and installation and operation of efficient treatment facilities (planning stage → gathering opinions → plan confirmation → implementation → evaluation → feedback).

The waste optimization strategy contributes to the efficient calculation of the business size and financial resources for installation waste treatment facilities. It can promote qualitative advancement and life extension, so it is reasonable to consider it first when promoting waste-related projects.

The main contents and implementation plan of the project are as follows.

[Table 6-4] Overview Linked Project (4)

Overview	- Establishment of strategies to improve the efficiency of waste treatment and minimize financial investment
Participants	- Government, local government, and recycling companies
Finance	- Waste charge, EPR contribution, other environmental taxes
Contents	- Identification of the status of public and private waste treatment facilities and review of optimization index - Adjustment of optimization index for each treatment facility by region - Separation discharge base and waste treatment facilities and facilities new installation and introduction demand
Advisory	- KOTRA and K-eco, consulting firms in Korea

5. Project for introducing a recycling station

A recycling station is a permanent collection facility that can separate, discharge, and store recyclables. Recycling stations are primarily installed in areas with priority for separation and discharge, and are equipped with rain-shielding facilities and various separate collection boxes. The recycling station aims to create a pleasant environment based on eco-friendly management and economical collection of household waste.

The recycling station project can increase the economic efficiency of recycling by providing a basis for separating and discharging recyclable resources. Additionally, it will be possible to contribute to revitalizing the atmosphere in which residents can voluntarily participate in improving the living environment, restoring a sense of community, and practicing resource recycling in daily life.

The main contents and implementation plan of the project are as follows.

[Table 6-5] Overview Linked Project (5)

Overview	- Support for the installation of permanent collection facilities that can separate, discharge, and store recyclables.
Participants	- Government, local governments, recycling companies
Finance	- Payment by waste recycling companies (regions with high economic efficiency) - Support for national treasury and environmental tax (regions with low economic efficiency)
Contents	- Implementation of pilot project and supplementation - Establishment of a supply plan (in the city center, priority supply to mass-generating sources, supply to small-scale sources)
Advisory	- KOTRA, Engineering companies (Union City Co., Ltd. ACI, TIPPLE(only EPS), consulting firms in Korea

6. Project Education for Separate discharge

It is necessary to conduct theoretical education and experience activities on the separation of recyclables for the entire nation to reinforce the awareness of the necessity of proper resource separation and recycling.

The main contents and implementation plan of the project are as follows.

[Table 6-6] Overview Linked Project (6)

Overview	- Education on the separation of waste
Participants	- Government, environmental groups, schools, ASEPLAS, recycling companies, all citizens (schools, public institutions, military bases, self-employed, etc.)
Finance	- Waste charge, EPR contribution
Contents	- Development of separate discharge education content and publication and distribution of guidelines - Establishment of an education promotion plan for the whole nation (broadcasting, classes, public relations, etc.) - Separate discharge guidance and monitoring
Advisory	- KOTRA, KWASTE

7. Project of Regulation of packaging material and structure

For the smooth recycling of EPS and PP, they should be manufactured in a state that is easy to recycle. For this purpose, it is necessary to regulate the standards of the material structure of packaging materials.

The main contents and implementation plan of the project are as follows.

[Table 6-7] Overview Linked Project (7)

Overview	- Establishment of regulations on packaging material structure
Participants	- Government, ASEPLAS, Obligatory producer
Finance	- EPR Contribution
Contents	- Provision of regulations on the structure of recycled materials for each packaging material (benchmarking Korea) - Establishment of material structure evaluation system and preparation of operation plan
Advisory	- KOTRA, K-eco, KPRC. KORA

8. Project of Standard of Obligatory use PCM and Development of quality standard

Although the law for the obligatory use of recycled materials has been enacted, there are no specific standards for use according to the extent to which recycled materials are used or the proportion of recycled materials. Therefore, it is necessary to develop standards for the obligatory use of recycled materials by applying international standards.

The main contents and implementation plan of the project are as follows.

[Table 6-8] Overview Linked Project (8)

Overview	- Development of standards for quality and Obligatory use of recycled materials
Participants	- Government, ASEPLAS, recycling companies, Obligatory producer
Finance	- Waste charge, EPR contribution, other environmental taxes
Contents	- Development of quality standards for Ecuadorian EPS and PP recycled materials - Introduction of certification according to ISO 14021 and establishment of the certification system
Advisory	- Ministry of Commerce, Industry and Energy

9. Project of installation Recycling Facility

Projects to promote the introduction of EPS and PP recycling devices and facilities should be promoted. Unfortunately, no company in Ecuador can manufacture EPS and PP recycling facilities, so importing technologies from Korea and Hong Kong is necessary.

The main contents and implementation plan of the project are as follows.

[Table 6-9] Overview Linked Project (9)

Overview	- EPS, PP sorting recycling facility installation
Participants	- Government, ASEPLAS, recycling companies,
Finance	- Payment by waste recycling companies (regions with high economic efficiency) - Support for national treasury and environmental tax (regions with low economic efficiency)
Contents	- Implementation of pilot project and supplementation - Establishment of a supply plan (in the city center, priority supply to mass-generating sources, supply to small-scale sources)
Advisory	- KOTRA, Engineering companies (Union City Co., Ltd. ACI, TIPPLE (only EPS), consulting firms in Korea

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Ministry of Economy and Finance (MOEF)
Sejong Government Complex, 477, Galmae-ro, Sejong-si 30109, Republic of Korea
Tel. 82-44-215-7747
www.moef.go.kr

Korea Trade-Investment Promotion Agency(KOTRA)
13, Heolleung-ro, Seocho-gu, Seoul, Republic of Korea
Tel. 02-3460-7522
www.kotra.or.kr

Knowledge Sharing Program (KSP)
www.ksp.go.kr