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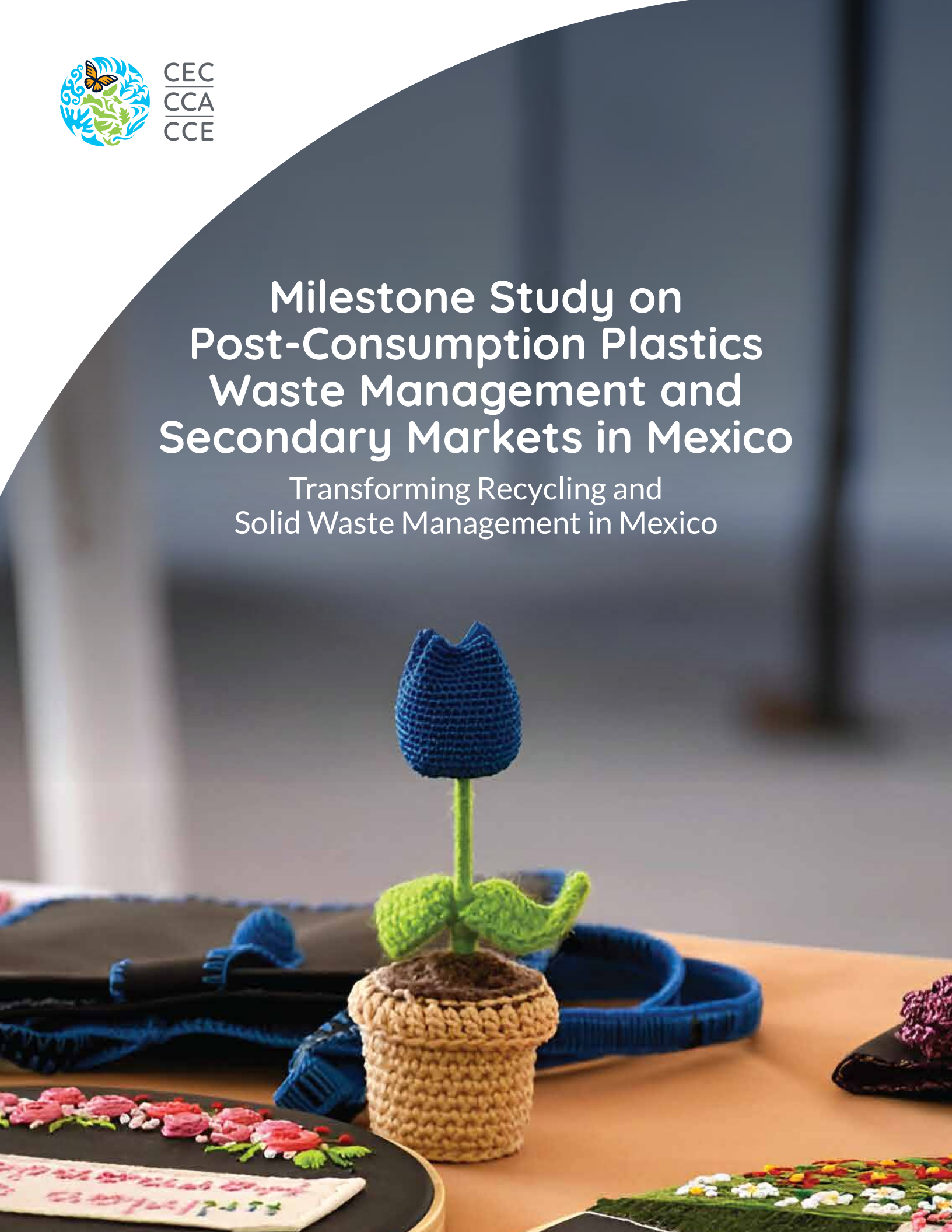
Milestone Study on Post-Consumption Plastics Waste Management and Secondary Markets in Mexico

Transforming Recycling and Solid Waste Management in Mexico



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Acronyms and Abbreviations

AMEE	*Asociación Mexicana de Envase y Embalaje, A.C.* (Mexican Association of Containers and Packaging, A.C.)
AMIA	*Asociación Mexicana de la Industria Automotriz, A.C.* (Mexican Association of the Automotive Industry, A.C.)
AMIRPAC	*Asociación Mexicana de la Industria de Reciclaje de Plástico, A.C.* (Mexican Association of the Plastic Recycling Industry, A.C.)
AMRRE	*Asociación Mexicana de Recicladores de Residuos Electrónicos, A.C.* (Mexican Association of Electronic Waste Recyclers, A.C.)
ANIPAC	*Asociación de Industrias del Plástico, A.C.* (Plastics Industry Association, A.C.)
ANIQ	*Asociación Nacional de Industria Química, A.C.* (National Chemical Industry Association, A.C.)
CEC	Commission for Environmental Cooperation
CNGM	*Censo Nacional de Gobiernos Municipales* (National Census of Municipal Governments)
DBGIR	Basic Diagnosis of Integral Waste Management
DENUE	*Directorio Estadístico Nacional de Unidades Económicas* (National Statistical Directory of Economic Units)
DOF	*Diario Oficial de la Federación* (Official Journal of the Federation)
GDP	Gross Domestic Product
ECOCE	*Ecología y Compromiso Empresarial, A.C.* (Ecology and Business Commitment, A.C.)
Inboplast	*Asociación de Industriales de Bolsas Plásticas de México, A.C.* (Association of Plastic Bag Industrialists of Mexico, A.C.)
INECC	*Instituto Nacional de Ecología y Cambio Climático* (National Institute of Ecology and Climate Change)
INEGI	*Instituto Nacional de Estadística y Geografía* (National Institute of Statistics and Geography)
LGEEPA	*Ley General del Equilibrio Ecológico y la Protección al Ambiente* (General Law on Ecological Balance and Environmental Protection)
LGPGIR	General Law on Prevention and Integral Management of Waste
Mexbeb	*Asociación Mexicana de Bebidas* (Mexican Beverage Association)
NGO	Non-governmental Organization
NOM	Mexican Official Standards

PASA	Promotora Ambiental, S.A. de C.V.
POE	*Periódico Oficial Estatal (Official State Newspaper)*
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of Environment and Natural Resources)
UNEP	United Nations Environment Program

Definitions

ABS	Acrylonitrile, butadiene and styrene
Apparent consumption	The sum of domestic production plus imports minus exports
Braskem Idesa	Petrochemical company producing polyethylene in Mexico
CC	Collection center
CE	Circular economy
CSi	Controlled site. Site unsuitable for final disposal that meets the specifications of a landfill, but does not meet the waterproofing specifications in accordance with NOM-083-SEMARNAT-2003
CSys	Cleaning system
EOL	End of life
EPR	Extended producer responsibility
FDS	Final disposal site. Place for final disposal of municipal solid waste and special handling waste
Food grade plastic	It is understood as the plastic used in the manufacture of a product or in contact with food, regardless of the type of waste involved
GP	Garbage picker. Individuals who perform plastic waste recovery activities at final disposal sites other than sanitary landfills. These pickers do not provide any type of receipt or invoice with a fiscal value
HDPE	High density polyethylene
HIPS	High impact polystyrene
KT	Kilotons
LDPE	Low density polyethylene
LDPE/LLDPE	Low density/Linear polyethylene
MI	Manufacturing industry
Monomers	Low weight molecules that are also the basic units or components of polymers
MSW	Municipal solid waste
Mt	Millions of tons
Mt CO_2eq	Millions of tons of CO_2 equivalent

PGP	Private garbage picker. Individual or legal entity that recovers plastic waste from large generators, industry, commerce or services. These pickers provide invoices with fiscal value
PBAT	Polybutylene adipate terephthalate (biodegradable material of synthetic origin, flexible and transparent, heat-resistant)
PBS	Polybutylene succinate (biodegradable material of synthetic origin, used in the manufacture of bottles and containers)
PCNPW	Per capita national plastic waste
PCR	Post-consumption recycled resin
PE	Polyethylene
PET	Polyethylene terephthalate
PHA	Polyhydroxyalkanoates (biodegradable biopolymer, used in the manufacture of bags or caps for certain products)
PLA	Polylactic acid
POM	Polyoxymethylene
Postindustrial	It is understood as a waste from a manufacturing process, which may be a defective finished product, scrap or scrap, which does not comply with its intended use or function
Post-consumption	It is understood as a waste from the daily use of consumers, mostly of domestic or commercial origin
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
R&D	Research and development
RI	Recycling Industry
SR	Shared Responsibility
Standards	Technical document—formerly considered Mexican Standards or NMX—that establishes rules, characteristics or test methods for products, processes or services, including terms, symbols, packaging, labeling and other specifications
TP	Thermoplastic resins
TS	Transfer stations
SHW	Special handling waste

SLF	Sanitary landfill. Infrastructure work involving engineering methods and works; they are final disposal sites that comply with NOM-083-Semarnat-2003
UCSi	Uncontrolled site. Site unsuitable for final disposal that does not comply with any of the specifications indicated in NOM-083-Semarnat-2003; it is generally known as a *garbage dump*, *open dump* or, in many cases, *landfill*
Other plastics	Plastic resins classified in category 7

Summary

As part of the *Transforming Recycling and Solid Waste Management in North America* project of the 2021 Operation Plan, the Commission for Environmental Cooperation (CEC) commissioned studies on the recycling and management of paper and cardboard waste, plastics and bioplastics for Canada, the United States and Mexico, with the objective of accelerating the adoption of circular economy (CE) practices aimed at promoting strategies for the sustainable management of these materials that generate economic and environmental benefits in the region.

This study describes the value chain of plastic waste for thermoplastic resins or *commodities*—the materials most involved in the manufacture, distribution and commercialization of plastic products in Mexico—and includes an overview of its infrastructure, operational management and associated markets. The current state of recovery and recycling is also documented, and public policies and applicable regulation within the framework of the circular economy are examined. It also provides a description of good practices and recommendations to strengthen the national system for managing these wastes. In the same way, best practices in waste management are identified, which could be implemented, considering the findings of this study.

A similar study focused on Canada and the United States was recently published,[1] with the aim to enable decision makers to know the current state of post-consumption plastic waste recycling in these countries.

Differences in waste control and management capacities determine recycling efficiency in the various states of the country, and between countries. Mexico does not follow the solid waste control and management patterns used in Canada and the United States so there are important differences in these patterns and in the way recovery and recycling of this post-consumption waste is carried out. Mexico does not charge fees for waste collection. This is a significant difference with respect to the other two countries and the budget allocated to infrastructure and public services for waste management.

Limited infrastructure, as well as poor operation and management of the cleaning services provided by municipal governments, have indirectly fostered the emergence of an informal sector, known as "*pepenadores*" or "garbage pickers" who, in exchange for a tip or the sale of these materials, recover waste.

These activities affect the waste management process, as irregular work is carried out in official vehicles and at local government disposal sites. Government-owned materials are extracted for personal use. This has consequences on the composition of the waste sent to the plants where the

[1] CEC (2024), *Transforming Recycling and Solid Waste Management in North America*, Commission for Environmental Cooperation.

waste destined for recycling must be extracted. This is an informal activity, but it is not illegal, as its social usefulness is recognized.

Garbage pickers do not issue invoices. They sell waste to other collectors with greater financial capacity, who have vehicles to transport it in large quantities to the collection centers. These collectors do issue invoices and meet their tax obligations, thus formalizing an informal activity. Materials recovered in this way are cleaner than those from a sorting plant, where mixed waste is received and processed.

Formal collection or recovery centers are entrepreneur-run micro- and small businesses who buy recovered paper and cardboard waste and sell it to the manufacturing or recycling industry.

In 2022, 1,683 kt of plastic waste were collected and recycled in Mexico, representing 25 percent of the apparent consumption of thermoplastic resins. High-density polyethylene (HDPE) is the most recovered material, with 574 kt, followed by polyethylene terephthalate (PET) with 466 kt. Both materials represent 62 percent of the total recycled.

Different actors are involved in the recovery of secondary material. In the domestic secondary market, companies are the main source of TP waste for recycling with 505 kt, followed by collection centers with 404 kt, dumps and gathering sites with 404 kt, the automotive sector with 202 kt and finally transfer centers with 168 kilotons.

Waste that comes from industry and the automotive sector are cleaner materials compared to the other sources mentioned. It should be mentioned that applications restrict the use of recovered material; for example, plastic impregnated with flame retardants, or antistatic products, is not useful for recycling in the food industry.

International trade in secondary materials is small compared to the domestic market. Mexico exports 148 kt of secondary material and imports 93 kt. These figures indicate that the country is a net exporter of secondary material. Despite the above, three-quarters of the apparent consumption of TP resins is neither collected nor recycled (5,012 kt). Polypropylene, linear low-density polyethylene (LLDPE) and other TP resins, including engineering resins, represent 67 percent of materials that are not recycled.

The main challenge for Mexico is to reduce the amount of plastic waste sent to final disposal sites (FDS) and recover it as close to the source as possible for recycling. Infrastructure planning for recycling begins with a reliable diagnosis of the generation and composition of solid waste in municipalities in the country; however, there are few generation and composition studies due to the cost involved in a detailed study, the frequency with which it is carried out and the obsolete regulation applied to determine the composition.

Management plans in Mexico are public policy instruments that fulfill a function like that of extended responsibility. However, these plans are implemented individually as a company, which

dilutes the effort and ends up in an administrative process that reduces the efficiency and effectiveness of large-scale actions. Finally, the regulatory structure in the country, although solid, is insufficient both to control informality, to reduce the social, economic and environmental inequality that occurs in the states, and for the control and the management of waste.

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1. Introduction

The United Nations Environment Programme (UNEP), in its *Global Waste Management Outlook 2024*, estimates that from 2020 to 2050 the generation of municipal solid waste (MSW) will increase globally from 2.1 to 3.8 billion tons, of which uncontrolled waste sent to a disposal site is estimated to increase from 1.45 to 3.66 billion tons, representing a growth of more than 1.5 times (see p. 77 of the UNEP report).

Semarnat's *Basic Diagnosis for Integrated Waste Management*, *2020*, estimates Mexican per capita waste generation of between 0.8 kg and 1.1 kg, total generation of 120,128 tons per day and waste collection coverage of 83.87 percent. Waste management by the public system is carried out in 47 plants, of which 26 are sorting or recycling plants, five are shredding plants, thirteen are compaction plants, 19 are composting plants and 5 are biodigestion plants.

There are 2,203 registered final waste disposal sites located in 1,722 of Mexico's 2,478 municipalities. Most of these sites do not comply with environmental regulations (NOM-083-Semarnat-2003).

Public infrastructure for the management of municipal solid waste, in addition to being insufficient, is in many cases accompanied by limited technical capacity, and the construction of new works does not solve much either because in a very short time they require major maintenance or stop operating, which leads to possible poor waste management. The country shows uneven growth in the management, treatment and final disposal of waste between different levels of government, as well as the presence of an informal sector that extracts plastic waste —mainly PET, PP and PE— at different points in the value chain and interacts commercially with the formal market.

With regard to plastics, ANIPAC reports in its *2023 Yearbook* that Mexico's plastics industry is comprised of more than 5,000 plastic processors, including companies in the maquiladora and export manufacturing industry, with more than 600 suppliers of resins and additives, machinery and various services, whose products cover a wide variety of consumer needs in packaging and containers, products for durable use and personal use, in applications in the automotive industry, electronic equipment, construction and applications for medical use and agricultural use, among others. There is also a recycling and collection industry that brings together more than 300 companies.

The resins produced or imported into Mexico by these companies are polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS or EPS), polyethylene terephthalate (PET) and engineering resins such as polyamides (PA), polycarbonate (PC), butylene terephthalate (PBT) and polyoxymethylene (POM), and are used in different applications.

In the market there are resins of origin other than oil or natural gas, known as bioplastics, which are used to manufacture biodegradable or compostable products. These resins are made from biomass, a renewable resource that includes materials such as starch, sugar cane and other organic waste;

the most common are polylactic acid (PLA), polyhydroxyalkanoates (PHA), polybutylene terephthalate adifate (PBAT) and polybutylene succinate (PBS). The latter two, although biodegradable, are manufactured from non-renewable sources, which distinguishes them from other bioplastics.

The industrial plastic chain supplies most economic branches with products that meet the basic needs of the population, in addition to being inputs from sectors such as, among others, food, automotive, construction, electrical and electronic, medical and agricultural sectors.

This study was prepared with the purpose of generating information comparable to data from Canada and the United States, which will allow us to consolidate joint strategies to improve the control and management of plastic waste.

2. Information Sources and Assumptions

The main sources of information for this study are the *2023 Yearbook* of the National Association of Plastics Industries, A.C. (ANIPAC), the Inboplast 2023 report: "Mexico Plastics Industry 2018–2022," and databases from INEGI, the Bank of Mexico, the Ministry of Economy and industry associations, and other referenced databases and information analyses.

INEGI reports manufacturing industry information in accordance with the North American Industrial Classification System (SCIAN), where the 102 plastic products are grouped into twelve families:

1. Manufacture of flexible plastic bags and films
2. Manufacture of pipes and fittings
3. Manufacture of rigid laminates
4. Manufacture of EPS foam
5. Manufacture of polyurethane foams, PU
6. Manufacture of plastic bottle manufacturing
7. Manufacture of other plastic products
8. Household products
9. Reinforced and non-reinforced auto parts
10. Packaging and containers
11. Products for industrial use
12. Other products with and without reinforcement

Information was also obtained in writing or in face-to-face or virtual meetings with the following associations: ANIPAC, Inboplast, ANIQ, AMEE, AMIRPAC, AMIA, AMREE, the recyclers' section of Ecoce and Braskem Idesa. During the working meetings with these associations, information,

opinions and knowledge of the plastics sector were exchanged which have helped to shape the content of the study.

For the elaboration of the value chain and identification of actors' activities, the main source of information is ANIPAC's *2023 Yearbook*, which mapped the number of participating actors, as well as data and technologies, in the plastics industry. Industries such as Braskem Idesa and associations such as ANIQ, AMEE, Ecoce and AMIRPAC confirmed the exchange of information with ANIPAC and validated the information shown in its *2023 Yearbook*.

The activities of the actors in the value chain correspond to the population where they are located, so that the type of population has a direct relationship with the infrastructure and technical operating capacity, as well as with the network of collectors or collection centers, the industry and the daily purchase and sale prices of recovered materials.

These are elements directly or indirectly present in the actions of plastic waste recovery and the amount of waste recovered; an example of this is that the weight of a waste determines whether or not a garbage picker collects it, because gathering a kilo is easier when each unit of the waste has a greater weight than another, such is the case of a bag *vs.* a bottle, and another example is knowing the market price per day (some collection centers expressed the convenience of having an official place to consult the prices of the material).

Mexico is a country with great cultural, historical and natural diversity. Its political organization considers 31 states and Mexico City, involves a population composition that combines different types depending on their characteristics and is identified as urban, rural and Indigenous, where urban and rural are clearly differentiated, but not Indigenous (this is a classification where individuals or families self-determine themselves as Indigenous but may reside within a rural or urban population and are expressed as a percentage). In the case of the urban population, there is rarely a high proportion of Indigenous individuals or families.

This study considers the percentage by type of population present in each of the states, so that those states with greater urban population can be clearly identified, followed by the rural population, to finally identify the percentage of the population that calls itself Indigenous. The two states that have a majority Indigenous population, exceeding 60 percent, are Oaxaca and Yucatán.

The percentage composition of the types of population—urban, rural and Indigenous—by state reported by INEGI for 2023 are presented in Table 1.

Table 1. Type and percentage of population by state in Mexico

State	Urban population (%)	Rural population (%)	Indigenous population (%)
Aguascalientes	84	16	6

State	Urban population (%)	Rural population (%)	Indigenous population (%)
Baja California	94	6	7
Baja California Sur	91	9	12
Campeche	75	25	47
Coahuila	92	8	2
Colima	90	10	13
Chiapas	49	51	37
Chihuahua	87	13	10
Mexico City	99	1	9
Durango	72	28	9
State of Mexico	87	13	16
Guanajuato	72	28	6
Guerrero	60	40	33
Hidalgo	57	43	37
Jalisco	88	12	7
Michoacán	71	29	21
Morelos	82	18	24
Nayarit	72	28	16
Nuevo León	96	4	6
Oaxaca	49	51	69
Puebla	73	27	33
Querétaro	79	21	13
Quintana Roo	90	10	33
San Luis Potosí	67	33	20
Sinaloa	76	24	9
Sonora	88	12	13
Tabasco	59	41	21
Tamaulipas	90	10	7
Tlaxcala	83	17	16
Veracruz	62	38	27
Yucatán	86	14	65
Zacatecas	63	37	5

Source: Prepared by the authors with data from INEGI (2023).

These population percentages do not add up to 100 percent, however, because of the way the Indigenous populations are included among the rural or urban population. In this way, public policies can consider the type of population in the development of infrastructure, waste control, and management.

The "Market Overview" section contains municipal-level data from INEGI's manufacturing industry survey. The general information provides information on the system, main components, and some results of waste management, but the amount of infrastructure for specific waste management cannot be clearly observed, which prevents the definition of a detailed correlation between type of population, infrastructure, service coverage, environmental quality and other aspects.

A Sankey diagram was used to analyze the flow of materials and wastes, comparable in structure to the diagrams presented in the corresponding studies in Canada and the United States. Its design used mainly data from the ANIPAC*2023 Statistical Yearbook*. In addition, import and export data were obtained from the United Nations Commodity Trade Statistics Database (*UN Comtrade Database*) and the US International Trade Commission database (*USITC DataWeb*) for the year 2022. The information on the trade balance of plastic waste corresponds to HS code 3915 "Plastic waste, parings and scrap" and data from trade between Mexico and the United States, under HST code 3915.90.10, were also used to identify the amount of polyethylene terephthalate waste.

For waste management, in general the urban population, and specifically the state capitals, have the most public and private infrastructure, followed by the rural population, although with unequal infrastructure, depending on the state where the infrastructure is located. Finally, the Indigenous population has the least infrastructure, often due to their remote location or the limited communication connections.

The main source of information for recycling data comes from the plastics industry itself, whose data appear in economic surveys of the productive sectors. These data and the application of numerical methodology allowed the better estimation of the values shown in this document.

It is very important to point out that the information presented by official sources, generally referring to the amount of waste disposed of in sanitary landfills (SLF), controlled sites (CSi) or uncontrolled sites (UCSi), does not allow us to specify the emission of waste by the various generators. The municipal reports for the preparation of the Basic Diagnosis of Integrated Waste Management (DBGIR) required the application of assumptions, indexes or indicators, and the more detailed analyses are mainly based on estimates.

3. Value Chain

3.1 General aspects of the plastics industry

The wide variety of plastics applications and uses allows them to be classified according to different criteria: by their chemical structure, such as homopolymers and copolymers, by their origin, natural

or synthetic, by their properties and thermal behavior, such as thermoplastics or thermostable (or thermosets), and even by their consumption pattern.

This study deals with plastics that are commodities or thermoplastic resins, which, owing to their thermal characteristics, are the most consumed polymers. This is due to their chemical properties, which remain stable when exposed to heat, and allow them to be used in a wide variety of applications and sectors. The growth in consumption is linked to various branches of industry, particularly food, dairy products, beverages, agricultural, construction and other household, industrial, automotive uses.

Also, the Society of the Plastics Industry has designated a universal identification code for such plastics: consisting of a triangle formed by three arrows enclosing a number. The triangle means that they are recyclable and the number corresponds to the materials that are recycled to a greater extent *(Encyclopedia of Plastics: XXI Century*, 2017).

The general characteristics of these polymers are shown in Table 2, according to their thermal properties, as well as their common uses and other advantages.

Table 2. Types of plastics identified as commodities and main characteristics of thermoplastic polymers

Code	Polymer	Advantages	Common uses
	Polyethylene terephthalate (PET)	Rigid and tough, resistant to corrosion and chemical action	Food packaging, bottles, textile fibers, base for magnetic tapes, etc.
	High Density Polyethylene (HDPE)	Dense, heavy and very resistant	Food and industrial packaging, bags, household appliance casings, toys and tubes
	Polyvinyl chloride (PVC)	Hard and tough, impervious, low flammability and corrosion resistant	Construction, pipes and valves, waterproofing films, cable sheathing
	Low density or linear polyethylene (LDPE or LLDPE)	Lightweight and flexible	Bags and wrapping, agricultural film, toys and household goods
	Polypropylene	Fairly rigid, resistant to stress and chemical action, good insulator	Industrial parts, electrical and electronic components, packaging and household items, toys, upholstery fibers, carpets and ropes
	Polystyrene (PS or EPS)	Fairly rigid, although with moderate mechanical resistance	Food containers, electrical appliance housings, acoustic and thermal insulation, packaging, toys

Code	Polymer	Advantages	Common uses
	Other plastics or engineering resins such as: Acrylonitrile butadiene styrene (ABS) Polycarbonate (PC) Polybutylene terephthalate (PBT) Polyacetals or polyoxymethylene (POM) Polyamides (PA)	Corrosion resistant, flexible, lightweight, non-toxic. High resistance to high temperatures and chemicals	Auto parts, computer cases, telephones and home appliances, water and sports accessories, aerospace engineering parts, medical and cosmetology items, furniture and water bottles, among others

Source: Prepared by the authors based on the ANIPAC *2023 Annual Report*.

The plastics industrial chain, which supplies most branches of economic activity, is made up of three main segments: support industries, processing industries and user sectors (see Figure 1).

The support industries are responsible for generating the raw materials and inputs necessary for the processing industries to produce plastic articles and sell them to the user sectors. These items are essential for various service sectors, as they enable the basic needs of the population to be met.

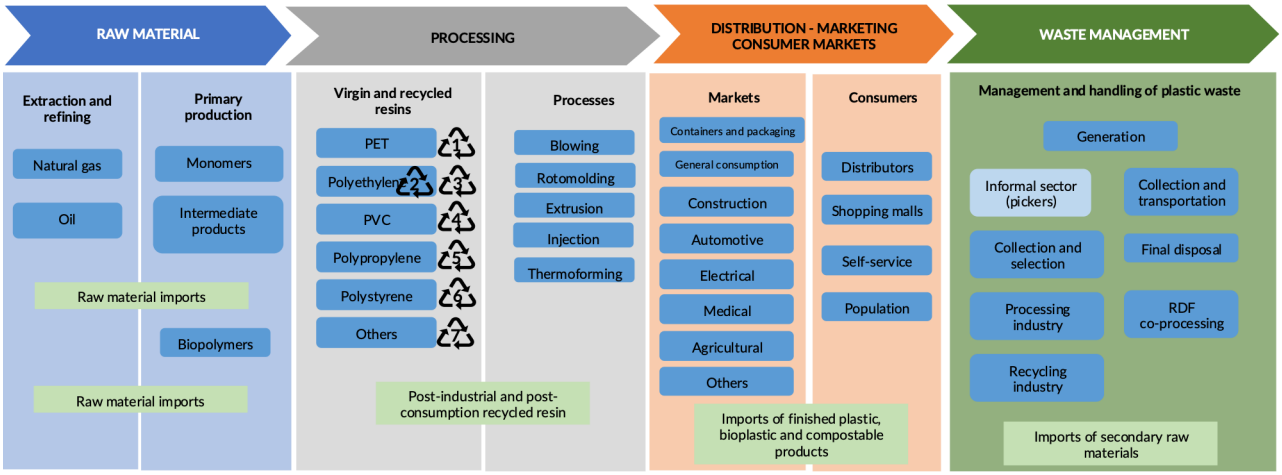
Figure 1. Economic activities of plastics, organized by industry branch

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*

3.2 Value chain components

The plastics value chain components in Mexico includes from the production of raw materials, followed by processing, distribution and marketing, to the generation and management of post-consumption waste and its reincorporation into the production chain, either in the same product or in other applications. This section also describes the actors and their roles within the value chain, as well as the waste cycle: raw material-product-waste-secondary raw material (see Figure 2).

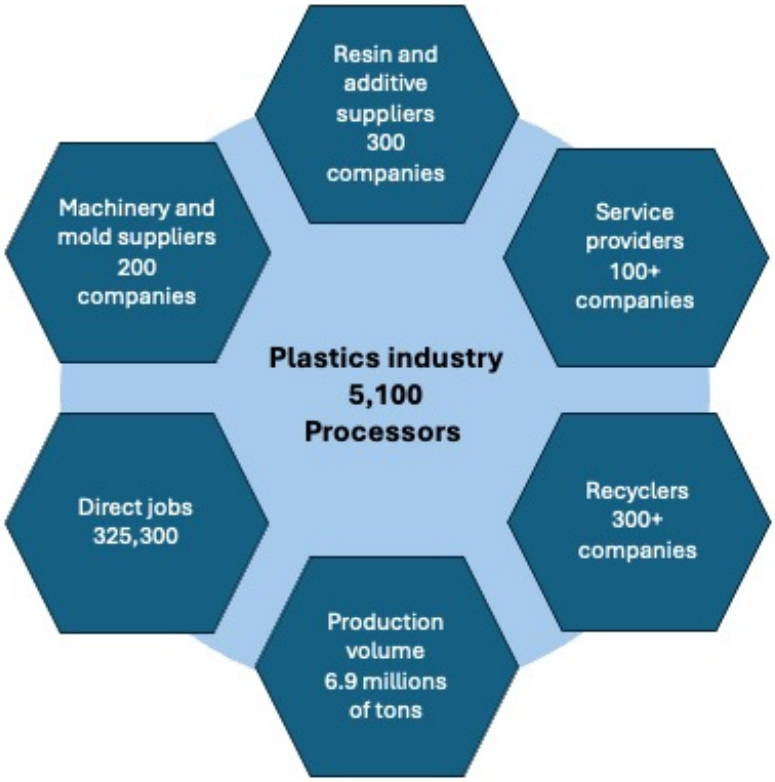
Figure 2. Plastics value chain



Source: Prepared by the authors, 2025.

The number of companies and actors involved in this value chain are numerous and their functions, multivariate. A company within the same industrial group or management plan can import finished products or raw materials to transform them into products, recycle its own process waste and, at the same time, use secondary raw materials, linking different actors within the company or group. The number of actors, mapped by ANIPAC, is shown in Figure 3, and the details of the activities in the various stages of the value chain are shown in section 3.3.

Figure 3. Number and categories of companies participating in the plastics industry



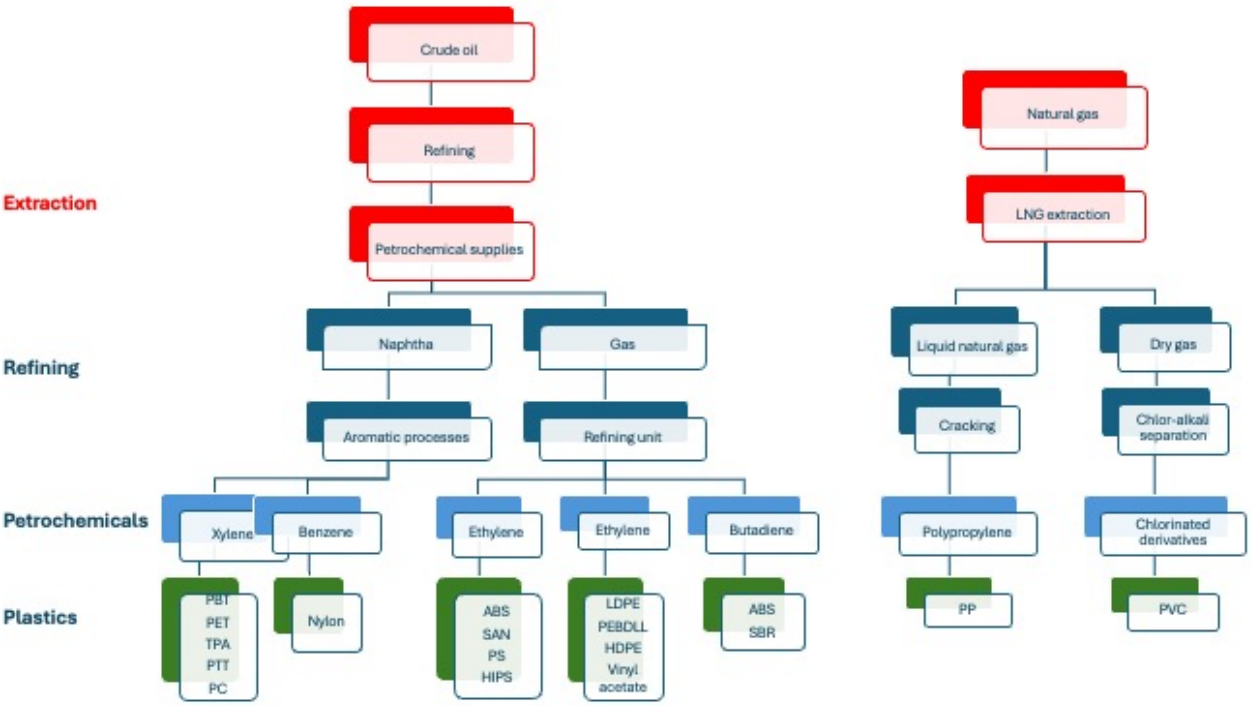
Source: Prepared by the authors based on information from the ANIPAC *2023 Statistical Yearbook*.

3.2.1 Raw materials

Renewable materials extraction and refining

The main players at this stage include the chemical and petrochemical industries, which extract oil and gas and transform them into intermediate products, such as ethylene, propylene, VCM, styrene, terephthalic acid, benzene, toluene, xylenes and polymers (commodities and engineering resins). In Mexico, oil activities are carried out by Petróleos Mexicanos (Pemex) and some foreign chemical or petrochemical companies that either have industrial plants or representative offices in Mexico (see Figure 4 and Table 3).

Figure 4. Obtaining plastics from petroleum



Source: Prepared by the authors with information from the *Encyclopedia of Plastics: XXI Century* (2017).

Table 3. Companies with representative offices or plants in Mexico

Companies with representative offices in the country	
M Advanced Materials Division (Dyneon LLC)	JSP International
Arkema	Lanxess Buna GmbH
Axson Mexico	Lubrizol (The Lubrizol Corporation)
Bamberger Polymers	Mitsui Chemicals, Inc
BASF	Polímeros y Materias Primas Internacionales (Polymat)
Celanese Corporation	Radici Plastics
Covestro-Policarbonates	Solvay Engineering Plastics
TPU Cobestro TPU	Solvay Polyamid & Intermediates
Down	Solvay Speciality Polymers
Dow Corning Corporation	Total Refining & Chemicals
Dupont Performance Elastomers	Trinseo
Eastman Chemical Company	United Soft Plastics, Inc.
Evonik Industries AG	Wacker Chemie AG

ExxonMobil Chemical	Wacker Chemie AG
Companies with plants in the country	
AOC LLC	INEOS Styrolution Group GmbH
Barnices y Resinas (BYR)	MG GruPPo Mossi & Ghisolfi
Braskem Idesa	Mexichem
Chemtura	Pemex Etileno
Cobestro PUR	PETStar
Dak Americas LLC	Reacciones Químicas
Dynasol Elastomers	Reactivos y Resinas
Epoxemex	Reichhold Chemicals, Inc
Feno Resins	Resinas y Materiales
Grupo IDESA	Resirene
Grupo Químico Industrial de Toluca	Sabic Americas, Inc
INEOS Styrolution Group GmbH	Sabic Innovative Plastics

Source: Prepared by the authors with data from the *Encyclopedia of Plastics: XXI Century*, volume II (2017).
Notes: These are companies that have a commercial office but do not carry out production activities in the country. The plants, in turn, produce resins or intermediate products for the manufacture of polymers, but do not carry out extraction activities.

The monomers–styrene, xylene, benzene, ethylene, butadiene, propylene and chlorinated derivatives–form polymers, which are materials consisting of many units that are repeatedly linked together in structure. These materials can be classified according to their origin, into natural, such as natural rubber and cellulose; semi-synthetic, when natural products are used; then transformed via chemical processes, such as nitrocellulose and rubber; and synthetic; such as polyethylene, polypropylene, polyamide or phenolic resin.

Resins produced in Mexico, or imported by companies, include polyethylene, polypropylene, polyvinyl chloride, polystyrene and polyethylene terephthalate, as well as engineering resins: polyamides, polycarbonate, polybutylene terephthalate, polyoxymethylene and others, all of which are used for different applications.

Resins of non-petroleum or natural gas origin are also available on the market. They are used for the manufacture of biodegradable or compostable products made from biomass, a renewable resource that includes starch, sugarcane and other organic materials produced by farmers or derived from organic product waste such as sugarcane bagasse.

Among the most common of these resins, known as bioplastics, are polylactic acid, polyhydroxyalkanoates, polybutyrate, polybutylene succinate: the last two are biodegradable but made from non-renewable sources.

The chemical companies mentioned above produce or import monomers to synthesize commodities or engineering resins, bioplastics, elastomers, blends and alloys, thermosets, and make the resins available to manufacturers.

3.2.2 Processing and manufacturing

In this link of the chain, virgin, post-consumption, or post-industrial recycled plastic resins are transformed into products through rotomolding, injection, extrusion, blow molding or thermoforming processes, and their products are grouped into the twelve product families mentioned in section 2: *"Information sources and assumptions."*

This activity is carried out by the processing or manufacturing industry of the main sectors, and the size of the companies varies. The 2019 Economic Censuses and INEGI's Annual Survey report more than 5,000 firms related to the twelve product families (see Table 4).

Table 4. Economic units by type of plastics industry, 2018-2022

Plastics industry	Units in 2018	Units in 2022
Plastic bags and films	931	881
Piping and connections	240	227
Rigid plastic laminate	136	144
Polystyrene products	235	240
Polyurethane products	135	132
Plastic bottles	217	234
Household products	539	533
Auto parts with and without reinforcement	424	394
Packaging and containers		684
Products for industrial use	1,020	1,090
Other products with reinforcement	214	231
Other products without reinforcement	406	392
Total	**4,497**	**5,162**

Source: Inboplast (2023), *Mexico Plastics Industry Report, 2018-2022*, INEGI Economic Census and Monthly Manufacturing Industry Survey (2022).

Based on the *Mexico Plastics Industry Report, 2018–2022*, by Inboplast, A.C., prepared by Consultores Asociados, the industry can be stratified according to personnel employed. Thus, 21 percent of the companies in the plastics industry that are classified as medium and large generate 86 percent of the jobs. Microenterprises employing fewer than ten people represent 54 percent of the universe of companies in the plastics industry. Small companies with a range of 11 to 50 employees account for 25 percent.

Plastic products are manufactured through various processes:

- Injection. This is the most commonly used process: the molten material is injected into a mold which, when solidified, gives the product its shape. It uses polyethylenes, polypropylenes and polystyrenes.
- Extrusion. It uses a helical screw conveyor, and the resins processed are polyethylenes, polystyrene, PET and acrylonitrile-butadiene-styrene, as well as engineering resins.
- Blowing. It is used to manufacture hollow parts by air pressure, especially PET and "parison" type containers made of polyolefins and vinyls.
- Thermoforming. It uses extrusion and is formed by temperature and pressure or vacuum to produce, among others, cups, trays, domes and packages. It uses polyolefins, polystyrenes and ABS (acrylonitrile, butadiene and styrene).
- Rotomolding. It is used in the manufacture of large hollow parts by heating and cooling molds and uses mainly polyethylenes.
- Other. For thermoplastic plastics, calendaring, compression, casting and spraying processes are applied, and for thermoset plastics, compression, casting, spraying, polyurethane foaming and injection-reaction molding processes are applied.

All plastics require formulation or use additives, such as antioxidants, bactericides, carbonates, catalysts, flame retardants, plasticizers, pigments and other materials, which allow them to improve their process efficiency and the final performance of the products. The addition of these compounds influences the recyclability or usefulness of the post-consumption waste, so for an application in the food industry, the source of post-consumption waste must come from the same application, that is, food-grade plastic to food-grade plastic. This means that, even if the material is PET, the application that generates it as waste should preferably be the same, since other applications could use additives or other compounds that make it unsuitable for recycling; for example, the use of flame retardant in the automotive or electronics sector invalidates the possibility of recycling in the food industry.

Design plays an important role in the new circularity strategies, so that a product should be functional, aesthetically pleasing, with a lower environmental impact and that it can be repaired or reconditioned for reuse as many times as possible before being discarded, and even, once this point has been reached, easily reused in the formation of secondary raw materials or reintegrated into the production chain as many times as possible. However, the design of a product is closely linked to the needs of users and the market, production conditions, transportation, logistics, cost and

availability of virgin or secondary raw materials, among others, which means that design changes are not always in line with reality.

3.2.3 Marketing, distribution and consumption

The commercialization of plastics will be described through their different consumer markets, which mainly include the containers and packaging, general consumption, construction, electrical and electronic, automotive, agricultural and medical sectors (see table 5):

Table 5. Main markets for plastic products in 2022 (thousands of tons)

Markets	2021	2022	% of participation
Containers and packaging	2,900	3,033	45.3
General consumption	995	1,045	15.6
Construction	703	729	10.9
Electrical and electronic	406	434	6.5
Automotive	536	561	8.4
Agricultural	228	238	3.6
Medical	153	170	2.5
Other	456	485	7.2
Total	**6,378**	**6,695**	**100**

Source: Prepared by the authors with data from the ANIPAC *2023 Statistical Yearbook*.

Containers and packaging

It is the largest market for plastics. Plastic containers help to significantly extend the shelf life of fresh food and beverages and allow more products to be shipped with less packaging material, reducing both food and packaging waste. The most common plastics are PE, PP and PET, which are used to manufacture flexible and rigid packaging, bags, bottles, containers and wrapping. In 2022, the use of plastic in the manufacture of these products represented 45.3 percent of apparent consumption, which according to the ANIPAC *2023 Statistical Yearbook* is equivalent to 3,033 kt or kilotons.

General consumption

This is the category with the second largest market share. The main uses of plastics include various every day, highly dynamic parts and types of plastic used in the manufacture of footwear, tarpaulins and textiles, toys, household items, diapers, sporting goods, among other general consumer products. The most common plastics in production are LLDPE, HDPE, PP, PET among others. In 2022, the use of plastic in these products represented 15.6 percent of apparent consumption, equivalent to 1,045 kt, according to ANIPAC data.

Construction

Plastic materials in residential and commercial construction—according to information from Plastic Technology Mexico—are, due to their strength, flexibility or lightness, mainly used as components of roofing, insulation, wall cladding, windows, pipes, wood composites, flooring and structures. Properties such as thermal insulation, heat resistance and dimensional stability of plastics such as PVC and silicones, among others, are greatly valued. In 2022, the share of plastics in this market registered 10.9 percent, equivalent to 729 kt, according to ANIPAC's *2023 Yearbook*.

Automotive

Manufacturers of plastic automotive parts take advantage of producing lightweight components such as fenders, containers, lamps, interior panels, engine covers and cable insulation. High impact resistance, rigidity and structural stability, as well as resistance to high temperatures, stand out as the main properties and physicochemical characteristics of these plastics, which can be integrated by various manufacturing processes, such as injection molding, blow molding, thermoforming and compression molding, allowing cost-effective production with high precision. The application of plastics in the automotive industry has made it possible to reduce the weight of vehicles and thus improve energy efficiency and reduce the generation of greenhouse gases (GHG). The American Chemistry Council indicates that an automobile is currently manufactured with about 50 percent plastic by volume, but only 10 percent by weight; thus, the apparent consumption of this market is equivalent to 8.4 percent (561,000 tons in 2022). It should be clarified that these values correspond to light vehicles (ANIPAC, 2023).

Electrical and electronic

Due to its insulating properties, corrosion resistance and versatility in the manufacture of components, plastics play a significant role in the electrical and electronics industry. According to the American Chemistry Council, plastic components are essential to advances in weight reduction and miniaturization of many electronic products, contributing to their strength and durability, protecting vital technology components and reducing material consumption in production and contributing to greater energy efficiency over the product's useful life. They are also used in the manufacture of cables, connectors, device housings and electronic components, among others.

According to Waste Trade, the most common plastics in this market are polyethylene, polypropylene, polyvinyl chloride, polytetrafluoroethylene, nylon and polycarbonate, and are chosen based on their properties and performance for a given application. Total plastic consumption in this market was 6.5 percent in 2022, equivalent to 561 kilotons (ANIPAC, 2023).

Medical

For plastics used in the medical sector, compatibility with the human body and the response to high standards of hygiene, safety, biocompatibility and functionality are considered. They are plastics that require high resistance to sterilization processes and preservation of their properties to be used in a wide variety of applications: medical devices, such as disposable syringes, catheters,

gloves, etc.; packaging materials, such as packages or containers that reduce humidity, oxygen and pollutants, and hospital equipment, such as bags and intravenous tubes.

The use of medical plastics provides numerous advantages, such as sterility, durability, being light weight and cost-effective, which cannot be easily substituted by alternative materials. The apparent consumption of this plastic was 2.5 percent in 2022, equivalent to 170 kilotons (ANIPAC, 2023).

Agricultural

The Mexican agricultural industry uses a wide range of applications to improve crop productivity, protect crops and optimize soil management. These applications are possible thanks to the lightness and high mechanical resistance to the environmental conditions in which they must operate. They are plastics used in multiple applications, such as irrigation systems, meshes, films, pipes, containers and trays for intensive crops, pest and weed control, containers and packaging of finished products or supplies, among others, allowing the sector greater productivity, reduced production costs and a better response to climate change. Total plastic consumption in this market was 3.6 percent in 2022, equivalent to 238 kilotons (ANIPAC, 2023).

In this sector, as in the medical industry, the participation of bioplastics is increasing due to the characteristics of these materials and their lower environmental impact derived from their biodegradability.

Other

There are other more specialized markets that are not addressed in this study, such as the aeronautical, fishing and tourism industries, which together accounted for 7.2 percent of total plastic consumption in 2022, equivalent to 485 kt according to ANIPAC's *2023 Yearbook*.

Distribution

Distribution schemes, a necessary link in the marketing of finished products, may be part of the company itself or of the customers, as is the case, among others, of automotive distributors, supermarkets and department stores, both wholesale and retail.

According to volume II of the *Encyclopedia of Plastics: XXI Century* (2017), of the Plastics Business Center, its 55 registered distributors (see Table 6 for some of the most important marketers) do not represent the totality of the companies in the plastics industrial sector in the country. It is important to consider that there are manufacturers that, without being listed as members of this guild, have their own infrastructure and integrated manufacturing and distribution models. This is the case of companies such as Braskem, Resirene and Quimisor, to name a few.

Table 6. Distribution companies in Mexico

Company	
Bamberger Polymers de México	Corporación Telch
Nexeo Solutions LLC	Poliformas Plásticas
Polímeros y Materias Primas Internacionales (Polymat)	Syrus Distributions
Vinmar Plastichem	Polímeros Nacionales

Source: Prepared by the authors with data from the *Encyclopedia of Plastics: XXI Century*, volume II (2017).

3.2.4 Waste management

Plastic waste generation

In Mexico, plastic waste generation is identified by its origin in:

- **Post-consumption**, for waste from the direct consumption of everyday products contained in plastic packaging to protect them, transport them or preserve their integrity or sanitation. This waste is disposed of through the cleaning system and is generally mixed with other waste to the point of being contaminated with liquids, solids or organic semi-solids, which makes it difficult to separate for recycling purposes.
- **Postindustrial:** Waste generated by industrial or commercial activities whose consumption reaches large quantities; it is generally identified as packaging waste (e.g., stretch wrap and large volume containers) and industrial process waste or scrap. These wastes are highly appreciated by the recycling industry because they can be easily separated and because of their quantities and cleanliness.

Post-consumption waste generation

Post-consumption generation is associated with the behavior of users of mainly food consumption products or goods, also increasingly associated with *e-commerce*. This waste is generated indirectly, to produce plastics for containers, packaging and packing, and is an indicator of the amount of waste generated by the final consumer.

The materials used to manufacture plastic bags and films, containers, packaging, thermoformed products, cutlery or straws, mainly used for the transportation, sale or consumption of prepared or fresh food, include PET, PP, PS, HDPE, LDPE, bioplastics, compostable and biodegradable, all collected and managed by the public or private cleaning system of municipalities.

Consumers purchase plastics along with electrical and electronic goods for the home, such as furniture, toys, cleaning utensils and general items that include them. And the same happens with cars and houses whose structures include plastics, all of which have a long life but are eventually discarded if they are already damaged or simply because their useful life is over. These wastes include PET, PP, PS, HDPE, LDPE, bioplastics, engineering plastics, specialty plastics, elastomers, blends and alloys, and thermosets. The recycling of these plastics, although they are the same in

composition, does not include the application of food contact, so they are not used by the food industry, although there are no restrictions to the contrary.

Post-industrial waste generation

These are wastes generated during the industrial process or in wholesale distribution and commercialization activities, and are generally handled by private collection systems such as PASA, Red Ambiental, Movilcontainer, Ambientum, ASECA, Terracycle, Caabsa Eagle and Tecmedmx, to mention some of the large companies, and by small companies associated with collection centers or private companies that have one or more vehicles for local collection. All this infrastructure is legal and issues invoices. In addition, more companies do not dispose of their process waste, mainly in the food industry, where the quality of the plastic used, with food grade standards, allows the manufacturer to make the most of its raw material. These wastes are generally PET, PP, PS, HDPE, LDPE, bioplastics and compostable.

Plastics with other applications, in the automotive, medical, construction, agricultural, electrical or electronic industries, have a longer life span and are generated as waste at the end of their useful life, are not associated with prepared or natural foods and are incorporated into consumer goods such as toys, furniture, cleaning utensils (brooms, squeegees, dustpans, buckets), boxes, ropes and nets, among others. Plastics used in these applications include polypropylene, high-impact polystyrene (HIPS), PS, HDPE, LDPE, engineering plastics, specialty plastics, elastomers, blends and alloys, thermosets and bioplastics.

Management of plastic waste at the end of its useful life

Post-consumption and post-industrial waste management is carried out through public or private cleaning systems and other private systems such as small individual or collective companies complemented by the informal sector, as described below.

Cleaning systems

Based on the *Political Constitution of the United Mexican States*, the cleaning system is a municipal public service that includes cleaning, collection, transfer, treatment and final disposal of waste and may or may not have an associated fee or tax; however, very few municipalities in Mexico charge for this concept, which is generally free of charge.

In terms of infrastructure for municipal solid and special handling waste, the country shows inequality in management and recycling among the states, inequality that is observed in local public policies, infrastructure, citizen participation and financing.

Public policies

Some states have stricter or more restrictive regulations on waste management, mainly in relation to single-use plastic, the application of which is uneven among user sectors: the strictest is that applied to industry. The states with a restrictive regulatory structure are Mexico City, Querétaro,

Quintana Roo and Yucatán, while there are states with more proactive regulation in terms of recycling and circular economy, such as Jalisco, Nuevo León, Estado de México and Guanajuato.

Since the formulation and progressive application of rules and regulations restricting the use of single-use plastics in various states, Mexico has experienced significant changes in the generation of its municipal solid waste. The bans have changed not only the volume of plastic waste, but also its composition, treatment and traceability.

Generation and composition of waste

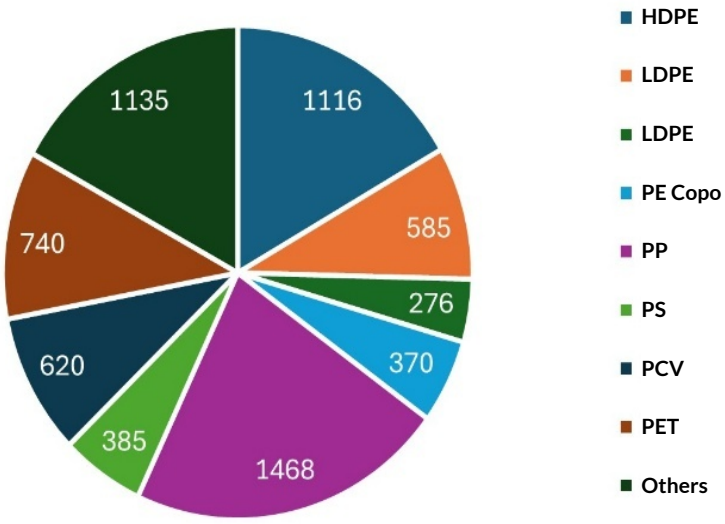
The 2020 Basic Diagnosis of Integrated Waste Management (DBGIR), which shows the average percentage composition of municipal solid waste, identifies plastic as follows:

- PET (2.63 percent)
- Rigid and film plastic (7.66 percent)
- Expanded polystyrene (1.55 percent)
- Polyurethane (0.55 percent)

This total figure of 12.29 percent is equivalent to 14,883 tons/day of discarded plastic waste. These wastes regularly contain those associated with the consumption of the general population. This composition includes containers, packaging, packing and other items such as toys, furniture, accessories, and occasionally also small automotive parts and small electrical or electronic devices (cell phones, battery eliminators), cleaning utensils (buckets, brooms) or medical or beauty items, to mention a few.

Likewise, although not directly accounted for, there is plastic waste in the automotive, construction and demolition, electrical and electronics, medical and agricultural industries whose generation calculation is assumed to be equivalent to the amount of plastics placed on the market by producers and importers, since at the end of their useful life they will be generated as waste. In general, ANIPAC reported in its *2023 Yearbook* the apparent consumption of thermoplastic resins with the distribution shown in Figure 5.

Figure 5. Apparent consumption of thermoplastic resins in Mexico in 2022 (thousands of tons)

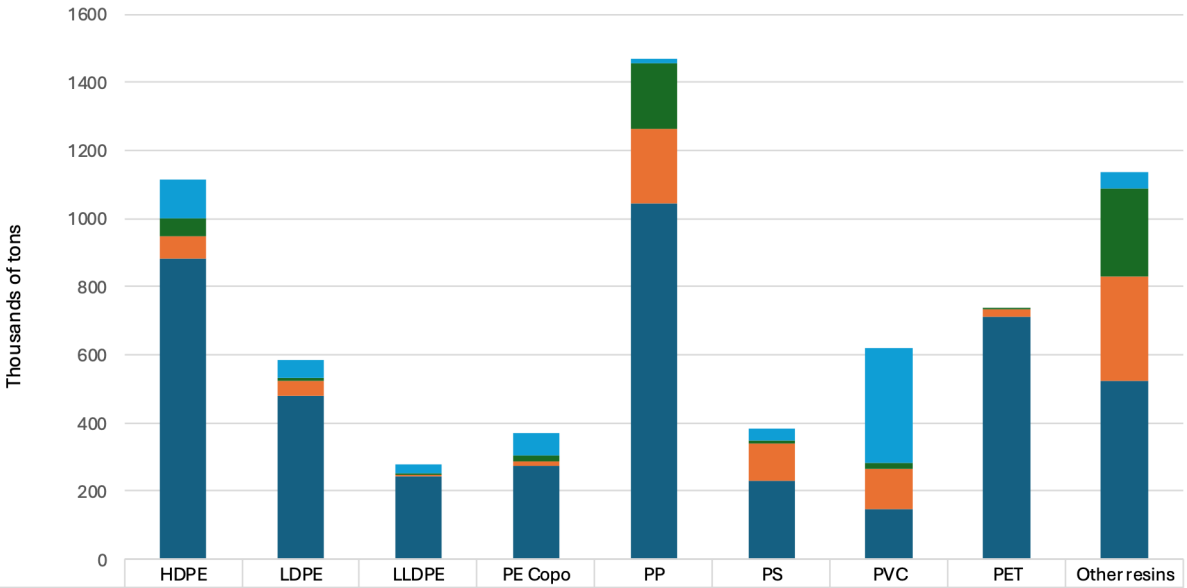


Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

All these plastics are used in various applications, of which conventional plastics are the most widely used in containers, packaging and packing. Figure 6, which shows the distribution of the various types of resin by application, shows polypropylene as the most widely used plastic in the consumer goods manufacturing sector, as it has the highest use in conventional applications, followed by the electrical and electronics, automotive and construction sectors.

Polyethylenes are plastics with high demand in conventional uses, and little use in other applications. PET is positioned as the third most consumed plastic, but with a more balanced use between conventional applications and the electrical and electronics and automotive sectors.

Figure 6. Apparent consumption by type of resin and application in Mexico in 2022 (thousands of tons)



	HDPE	LDPE	LLDPE	PE Copo	PP	PS	PVC	PET	Other resins
RCD	116	51	25	65	14	38	336		45
Automotive	50	11	3	18	190	9	21	7	259
RAEE	66	43	7	13	219	110	116	21	308
Conventional plastic	884	480	241	274	1045	228	147	712	523

Notes: CDW stands for construction and demolition waste, and EEEW for electrical and electronic equipment waste.
Source: Prepared by the authors with data from the ANIPAC *2023 Statistical Yearbook*.

Waste generation is assumed to be equal to waste production (see discussion in section 4.1 below).

It is worth mentioning that the restrictions on single-use plastics in the country had noticeable effects on the generation and composition of waste; INEGI (2025) reported a 55 percent decrease in the per capita generation of plastic waste between 2021 and 2025.

Infrastructure. This document considers public infrastructure such as the number of collection vehicles, transfer stations and final disposal sites, as well as private sector collection centers and industrial facilities to manufacture or recycle plastic waste. The broadest coverage of both sectors was always associated with urban areas, state capitals and metropolitan areas in relation to storage centers; for industrial areas, the most important aspects were communication routes and security of electricity supply.

The public infrastructure for management, treatment and disposal is municipal and, in general, built, operated and maintained by the public administration with funds mainly from budget allocations provided by the federal government to each state.

This public infrastructure handles the generation of 120,128 tons of waste per day in Mexico. Undoubtedly, the number of facilities is insufficient to handle the total volume of waste currently generated in the country. Most of them operate below their capacity, since financial and technical limitations mean that they are in poor condition or even out of operation.

An important element to improve the cleanliness of post-consumption waste in urban, rural or even Indigenous areas is containerization, since this infrastructure facilitates the activity of garbage pickers or *pepenadores* whose collaboration, although informal, is recognized throughout the recovery and recycling scheme, mainly for PET, PP, HDPE and LDPE.

Recycling has been modified as a result of bans and pressure from local, state, federal and even international governments, mainly for single-use plastics, which include materials such as PET, PP, PE, PS and products such as plastic bags, straws, cups, cutlery, plates and other items considered disposable.

Industrial recycling facilities consist mainly of the producing industry itself, which generally has its own recycling plants. They also have a network of collection centers that supply their plants with secondary raw materials, a scheme followed by the packaging industry to recover post-consumption and post-industrial waste and, if food grade, recycle it.

The private sector has also invested in recycling plants for PET, PP, HDPE, LDPE, PS, PVC and mixed plastics, which are used in the manufacture of panels, urban, domestic, office and tourist furnishings, where the material is not required to be food grade.

The distribution of these private facilities responds mainly to the availability of plastic waste for small collectors at distances of less than 15 kilometers and a collection network where road or rail communication is sufficient to cover the country.

It should be noted that garbage pickers and collection centers are the point where informal activity is formalized, because there the waste is bought and sold at market prices, and they are free to sell to whomever offers them the best price.

Formalization in the recovery of plastic waste occurs at the moment when the garbage picker sells to the first collection center, which must demonstrate that it acquires the materials from a formal source, a situation that requires better fiscal strategies and government support.

Recovery and recycling

In its fifth report, the National Agreement for the New Plastics Economy includes data provided by 77 companies, which put 739,072 tons of packaging on the market. Of these, around 50 percent corresponds to PET, which represents the use of 53 percent of the country's plastic containers and packaging, with a recovery rate of 60 percent. The Agreement also reports the recovery of 37 percent of the products placed on the market by its signatory companies.

The fourth report (2023) of the Agreement reported the management, through management plans, of 598,600 tons of plastic recovered that year, of which 46 percent corresponded to PET and 27 percent to high-density polyethylene.

ANIPAC's 2023 Report indicates that 1.68 million tons of plastics were recycled in Mexico, where 34.1 percent corresponded to HDPE, 27.7 percent to PET, 13.2 percent to PP and the rest to plastics such as LDPE, PVC, PS, EPS, engineering and others.

Recycled material originated mainly from companies (30 percent), collection centers (24 percent) and dumps and garbage pickers (24 percent). The percentages do not add up to 100 percent due to the overlap observed in the origin of the materials; for example, waste from companies may arrive at collection or transfer centers, so the values for these should be considered as a reference.

Costs

Public infrastructure for management, treatment and disposal is built, operated and maintained by the public administration with funds mainly from budget allocations provided to each state by the federal government. These budgets do not meet actual waste management and handling needs. They are limited by available funds.

The Basic Diagnosis of Integrated Waste Management (Semarnat, 2020) indicates that the cost of 434.03 pesos per ton of municipal solid waste collected, an amount reported by state programs of 167 municipalities in thirteen states, corresponds only to the operation of the collection service, which includes salaries, fuel and in some cases the maintenance of the units. The cost of 121.58 pesos per ton for final disposal reported in 84 municipalities in ten states includes salaries for personnel working at these sites and fuel for the machinery used. These costs reflect the poor condition of the infrastructure and operation of the country's disposal sites.

3.3 Value chain actors and forms of organization

The actors for each stage of the value chain are organized in associations, chambers, guilds, academia, and through public policy instruments such as Management Plans (see Table 7). It is important to clarify that some value chain actors are involved in one or more stages and their role varies according to the link in the chain in which they are located.

Table 7. Actors and their general characteristics

Actor	Characteristics
National oil producer	The only domestic oil and gas producer is Pemex, which carries out extraction, refining and petrochemical activities. Chemical companies located in Mexico transform basic refining or petrochemical compounds into intermediate products or monomers.

Actor	Characteristics
Chemical companies	They purchase or import refining products or petrochemicals to manufacture various types of plastics. Polymer manufacturers are also known as resin manufacturers. These actors are required to develop management plans for the recovery and recycling of post-consumption and post-industrial waste. The importers are part of some of the chemical companies with representation in Mexico and import, in addition to commodities, engineering plastics, elastomers, blends and alloys and thermosets, as well as finished products.
Processors	Also known as manufacturers, these are the companies that produce, by means of different industrial processes, all the plastic products used in different applications with the different polymers and their additives. They also have recovery capacity through their own supply chains, such as collection centers, and their network of individual or private garbage pickers. These actors, together with importers and chemical or resin companies, are required to develop management plans for the recovery and recycling of post-consumption and post-industrial wastes.
The marketing of plastic and its finished products to the final consumer is done through: 1. Large self-service chains 2. Department stores 3. Large distributors	The largest volumes in the marketing of plastic and its products move through large distributors. Small businesses would in any case be advised to adhere to management plans of larger companies. 1. They have distribution centers and record wholesale and retail operations. 2. This sector produces post-industrial waste associated with the packaging of the products it consumes. 3. The population generates post-consumption waste from packaging when purchasing a product or food, and disposes of mixed plastic waste in cleaning systems.
Consumers or users of plastic products	Consumption or use is carried out by the general population.
The waste management industry includes: Garbage pickers (GP) Private Garbage Pickers (PGP) Cleaning system (CSys) Collection Centers (CC) Manufacturing Industry (MI) Recycling Industry (RI)	GP. They recover post-consumption waste directly from controlled sites (CSi), uncontrolled sites (UCSi) or from local CSys collection vehicles. Waste is sold to other collectors with larger operations or to collection centers. PGP. They mainly recover post-industrial waste from large generators, industry, commerce or services, and sell this waste to CCs. CC. They buy and sell the recovered waste, reclassify it, compact it and send it to larger collection centers or to the manufacturing or recycling industry. MI and RI. They handle and reprocess post-consumption or post-industrial waste and manufacture new plastic products. Those in the food industry require post-consumption plastics used for food contact. The rest of the industry can use any source of post-consumption or post-industrial waste. This industry receives waste from the CCs.
Municipal Government Cleaning Systems (CSys) Private businesses and individual services	CSys. It provides collection, transportation and shipment services of household waste to FDS, and in some cases it includes large generators, industry, commerce or services. In some cases, the CSys have transfer stations (TS) and even sorting plants.

Actor	Characteristics
	Private companies and individuals. They have their own collection vehicles and provide waste collection and shipment services to final disposal sites (FDS). Private services generally do not deal with waste sorting: they only collect and dispose of waste. Some that collect separately send to CC and, when they collect mixed waste from the population, they dispose of it in final disposal sites.
Garbage pickers (GP)	GP. Individuals or families who collect plastic waste, mainly PET or PP bottles, at final disposal sites; some work on foot, others with tricycles and some with pack animals. They are informal, they do not issue receipts or invoices with fiscal value, theirs is a subsistence activity. In large cities, GPs are hired by the driver of a collection vehicle to separate commercial waste, PET, HDPE, PP, PS bottles, on the road. The market is starting to open up for the purchase and recycling of PET, PP, HIPS, PS trays.
Private garbage pickers (PGP)	Individuals or companies that recover plastic waste from large generators, industry, commerce or services, with the capacity to sign contracts and issue tax invoices. They have at least one vehicle or a fleet of vehicles, some only transport and dispose of waste in the FDS and provide services to closed or open housing developments. In addition to plastic bottles, the waste they recover includes stretch wrap and, although they do not carry out fine separation, they at least separate bottles from other post-consumption or post-industrial waste.
Individual private collection centers	These are unique facilities that have scales and carry out activities for the purchase and sale of clean waste. They aren't owned by a big company and they sell their materials to the highest bidder. These are facilities with little infrastructure and in some cases are close to controlled sites (CS) and uncontrolled sites (NCS), or on the routes of collection vehicles, and are also close to transfer stations (TS) or sorting plants. Generally, they separate and temporarily store post-consumption waste for shipment to other collection centers with greater capacity or directly to the manufacturing or recycling industry. The purchase price is the commercial value on the day of the transaction and, although there is no price information system, all participants handle a similar price according to the area where they are located. The price changes every day.
Business collection centers	These are facilities with some type of fixed scale or vehicle weighing system, a sorting belt and a compactor. Some CCs belong to the MI, which seeks to supply post-consumption or post-industrial waste that is better cleaned and of higher-quality material. The MI and, in some cases, the RI, organize their own networks of collection centers. They buy and sell post-consumption and post-industrial waste on a wholesale basis; the market value is current, and the value is determined in an unclear manner.

Actor	Characteristics
Selection Plant	Some municipalities have these facilities to sort waste with commercial value, such as PET, PP, HDPE, LDPE and PS. Their efficiency is generally low because they receive waste that has undergone previous manual sorting processes by GPs in collection vehicles. The technologies applied generally include a sorting belt and vertical and horizontal compactors, as well as forklifts. Almost all of the plants are owned, operated and maintained by the local government.
Management plan promoters	Although it is a public policy instrument, its design and implementation allows the coordination of actions of one or several companies or actors in the value chain to address a waste stream. In the case of plastic, the focus can be on PET or plastic waste generated by shopping malls or self-service stores that generate various types of plastic and other waste, including PP, HDPE, LDPE, PS and film or stretch wrap. The obligation of these plans is based on the LGPGIR and the federal standard NOM-161-Semarnat-2011 and local laws and regulations. In the plastics sector, the Ecoce organization promotes the management plan for the water and carbonated beverage sector, and its objective is to deal with post-consumption PET container waste. It is currently seeking to include bags and films. Mexico City requires the plastics industry to develop and implement management plans mainly for single-use plastics. This instrument considers shared responsibility, and although it has elements that allow the participation of federal or local authorities, they do not participate and are restricted to registering, following up or controlling its implementation. The instrument is a reflection of corporate responsibility, but falls short of being a formal EPR scheme due to its voluntary nature in most of the country.
Sanitary landfill (SLF) owners	In the country, these sites are either public or private, and in both cases must comply with the provisions of NOM-083-Semarnat-2003 and must not allow the entry of GPs or PGPs. Now, there are very few such classified sites in Mexico.
Controlled Site (CSi) Uncontrolled Site (UCSi)	Both are sites that do not comply with NOM-083-Semarnat-2003, mainly related to the geomembrane or insulating material of the site. The actors are generally public or some private with permission from the local authority. GPs are allowed to enter these. The recovery of plastic waste includes mainly bottles of any material, which are sold at commercial prices. The organization of the site and the gathering are carried out with the authorization of the municipality; most of the municipalities have union organization schemes within the group of garbage pickers.

Source: Prepared by the authors.

4. Market Overview

4.1 Overview of material flows and performance

According to INEGI figures, in 2022 the plastics and rubber industry's share of national GDP was 0.69 percent. Specifically, the manufacture of plastic products contributed 2.5 percent of the 2022 manufacturing industry's GDP.

Regarding employment generation, according to INEGI's Monthly Manufacturing Industry Survey, the plastics industry reported 221,538 jobs in 2022. Comparing this figure with the 217,682 jobs registered in 2021, an increase of 1.77 percent or 3,856 more jobs is observed. The production value of the plastics industry increased from 325 billion pesos (constant 2018 base year) in 2021 to 333 billion pesos (constant 2018 base year) in 2022, a real annual increase in production value of 2.6 percent.

Based on statistics from the National Association of Plastics Industries (ANIPAC, 2023), 3,508 kt of thermoplastic resins were produced in Mexico in 2022, a slightly lower production than the previous year (3,533 kt). However, although the volume of domestic production decreased by 0.7 percent, the increase in real terms in the value of production could be explained by the growth in the share of higher value-added plastic products, such as household appliances and polystyrene products.

Table 8. Value of production by segment (thousands of constant Mexican pesos, base year 2018)

Description	2021	2022	Variation (%)
Bags and films	68,363,811	70,877,718	3.68
Piping and connections	14,548,891	13,852,378	–4.79
Polystyrene foams and products	23,251,695	25,116,690	8.02
Foams and urethane products	20,454,066	18,789,745	–8.14
Plastic bottles	37,370,928	38,941,000	4.20
Household plastic products	22,793,754	24,620,991	8.02
Plastic auto parts	71,939,403	72,153,511	0.30
Packaging and containers	25,419,111	26,485,242	4.19
Products for industrial use	40,369,856	42,023,325	4.10
Total	**324,511,516**	**332,860,600**	**2.57**

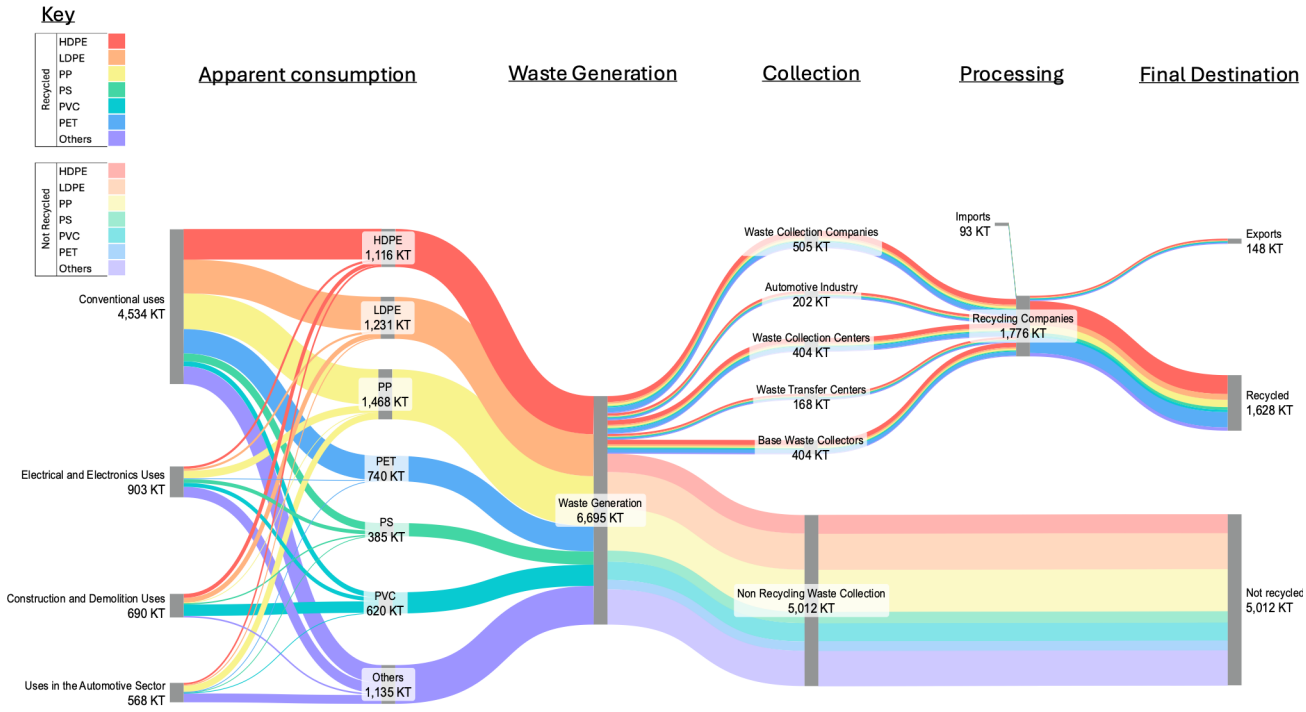
Source: Prepared by the authors with information from INEGI's Monthly Manufacturing Industry Survey and the National Consumer Price Index published by Banco de México.

In terms of foreign trade, in 2022, 4,727 kt were imported and 1,540 kt of these materials were exported, data that reveal the country as a net importer. Apparent consumption of thermoplastic resins during 2022 was 6,695 kt. Domestic production of these resins reached 52 percent of apparent consumption. On the other hand, there is installed capacity to produce 4,870 kt, and its utilization amounted to 72 percent. In monetary terms, Mexico has a trade deficit of more than 9.089 billion dollars in plastic products, resulting from the difference between exports (9.389 billion dollars) and imports (18.475 billion dollars), these values being for 2022. The sum of imports of resins, plastic products and capital goods is greater than 35.556 billion dollars, while exports barely exceed 13.456 billion dollars. T-MEC partners, especially the United States, are the origin of seven out of every ten dollars of imports (ANIPAC, 2023).

Figure 7 summarizes in a Sankey diagram the flow of thermoplastic resins in Mexico for 2022. The diagram depicts material flows from left to right. There are four initial nodes representing the industrial uses of these resins in Mexico (1: conventional uses; 2: electrical and electronic; 3: construction and demolition; and 4: automotive sector).

Seven nodes are presented below, representing the apparent consumption of the seven TP resins with the highest consumption, according to their universal identification code. This is followed immediately by the waste generation node, which in magnitude is assumed to be equal to the apparent consumption of TP resins disaggregated in the previous nodes. To the right of the waste generation node, it is possible to distinguish the flow of waste that is collected and not recycled, as well as a flow of waste that is collected by different actors, sent to recycling companies, processed and finally recycled or exported. The components of this diagram will be explained extensively in the following sections.

Figure 7. Plastic waste streams by resin type and industrial application in Mexico, 2022 (kilotons)



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*, UN Comtrade and USITC DataWeb.

4.2 Plastic applications and use in Mexico

In order to analyze the material flows in the country, this section identifies the applications and industrial end use of plastics according to the following four categories:

1. **Conventional uses of plastic (CU).** Includes the use of resins in the production of packaging and other conventional uses; for example, inputs for the production of toys, footwear, lids, etc.
2. **Uses in electrical and electronic equipment (EEU).** Includes the use of resins in the production of household appliances, electrical and electronic devices, medical equipment, cable and wire.
3. **Uses in the automotive sector (ASU).** Includes the use of resins in the production of auto parts.
4. **Uses in construction and demolition (CDU).** Includes the use of resins in the production of pipes, tanks and cisterns, foamed products for construction, etc.

According to ANIPAC data (2023), the industrial end use of plastics in Mexico was distributed as shown in Table 9:

Table 9. Applications and uses of plastic in Mexico in 2022 (kilotons)

Industrial end uses	Abbreviation	kt	Percentage
Conventional uses	CU	4,534	68
Electrical and electronic uses	EEU	903	13
Construction and demolition uses	CDU	690	10
Automotive sector uses	ASU	568	8
Total		**6,695**	**100**

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

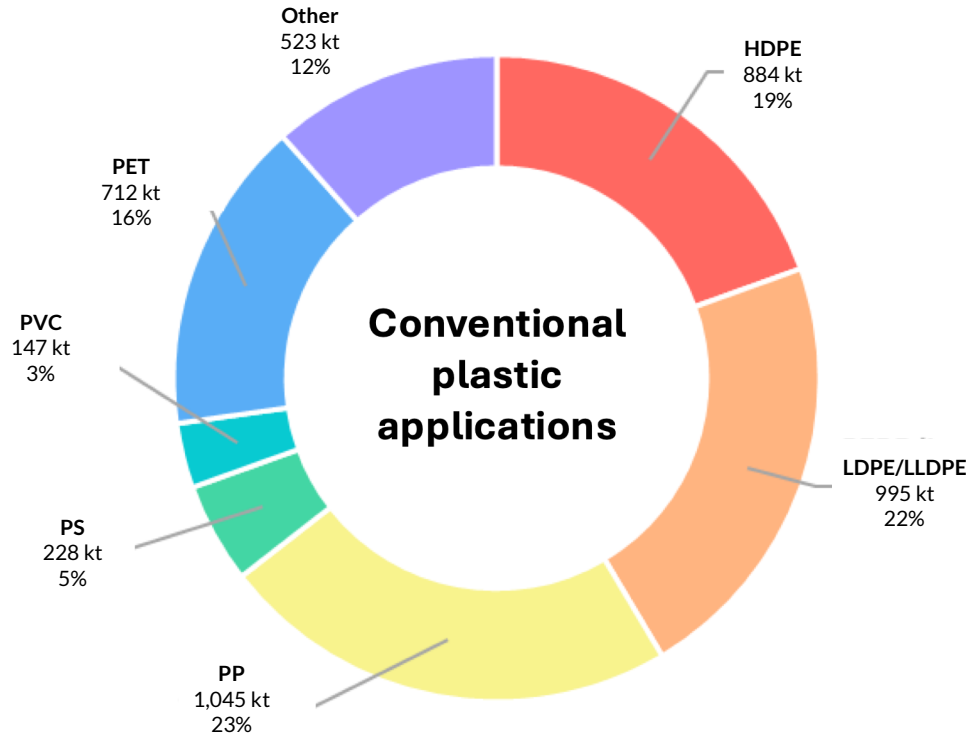
Packaging and packing, the most widespread applications, was grouped as conventional plastics and 4,534 kt (68 percent) of plastic materials were used in their production. In second place is plastic contained in electrical and electronic products, which accounted for 903 kt (13 percent) of materials. In construction and demolition products, 690 kt (10 percent) of plastic materials were used, and in the automotive sector, 568 kt (8 percent) of thermoplastic resins were used. These data correspond to vehicle manufacturing, not to the registration of waste generated by end-of-life vehicles, because in Mexico the disassembly of these vehicles is not carried out in an orderly recycling scheme: disassembly is rather a daily activity without a focus on intensive recycling.

In the Figure 7 Sankey diagram, these data appear at the four initial nodes of the material flows.

4.2.1 Types of resin by industrial application and use in Mexico

According to the classification of the final industrial use of plastic, Figure 8 shows the composition of resins in the conventional uses of the material. The resin most used for this purpose is PP with 1,045 kt (23 percent of the total), followed by LDPE-L with 995 kt (22 percent of the total), HDPE with 884 kt (19 percent of the total), PET with 712 kt (16 percent of the total), other uses with 523 kt (12 percent of the total), PS with 228 kt (5 percent of the total) and PVC with 147 kt (3 percent of the total).

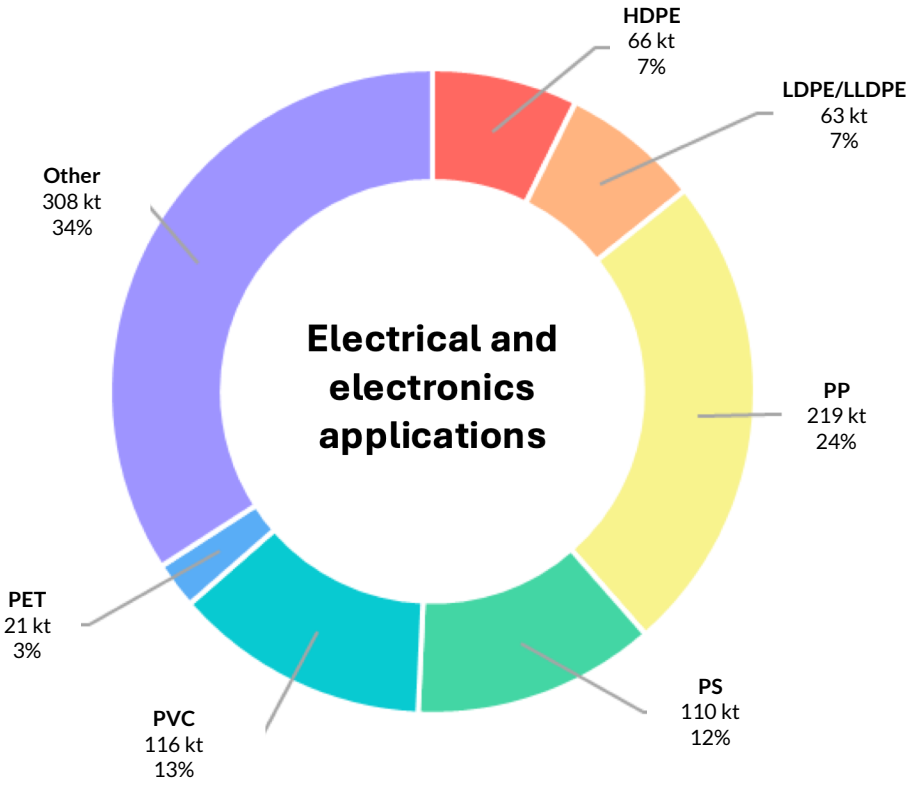
Figure 8. Resin types in conventional plastic uses, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Figure 9 shows the composition of resins used in electrical and electronic devices. The largest share is made up of other resins, with 308 kt (34 percent of the total), mainly engineering resins (due to their flexibility and high resistance to high temperatures and chemical products), followed by PP with 219 kt (24 percent of the total), PVC with 116 kt (13 percent of the total), PS with 110 kt (12 percent of the total), HDPE with 66 kt (7 percent of the total), LDPE-L with 63 kt (7 percent of the total) and PET with 21 kt (3 percent of the total).

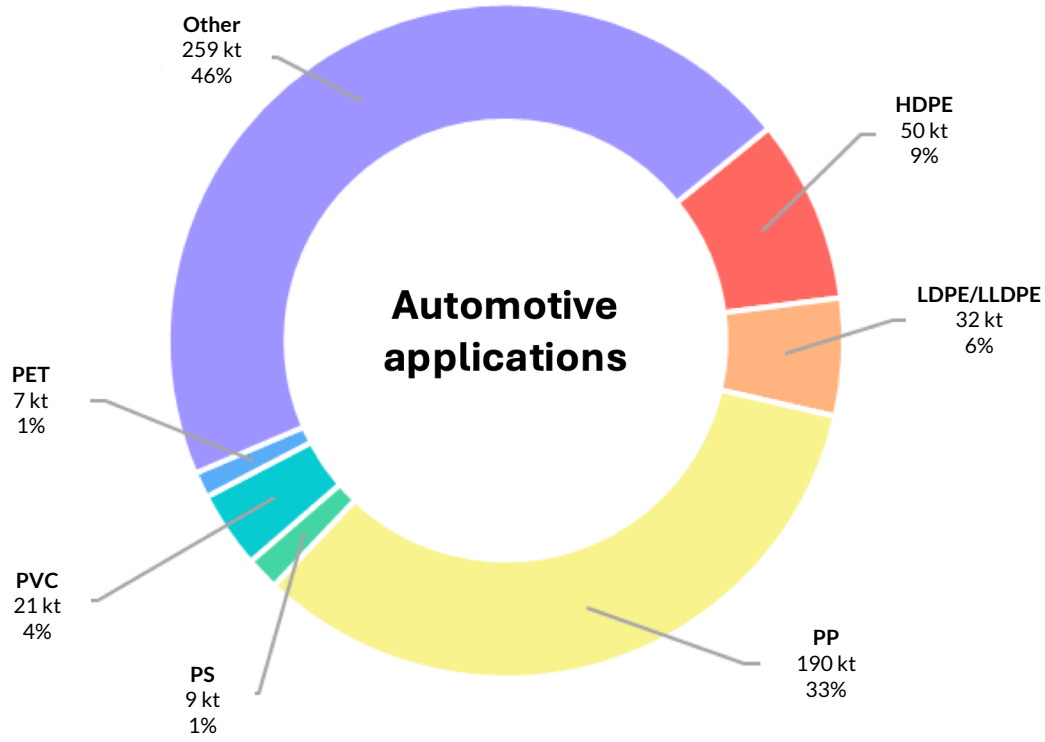
Figure 9. Types of resins in electrical and electronic applications, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Figure 10, which shows the composition of resins used in the automotive sector, shows that the largest share corresponds to other resins with 259 kt (46 percent of the total), mainly engineering resins, followed by PP with 190 kt (33 percent of the total), HDPE with 50 kt (9 percent of the total), LDPE-L with 32 kt (6 percent of the total), PVC with 21 kt (4 percent of the total), PS with 9 kt (1 percent of the total) and finally PET with 7 kt (1 percent of the total).

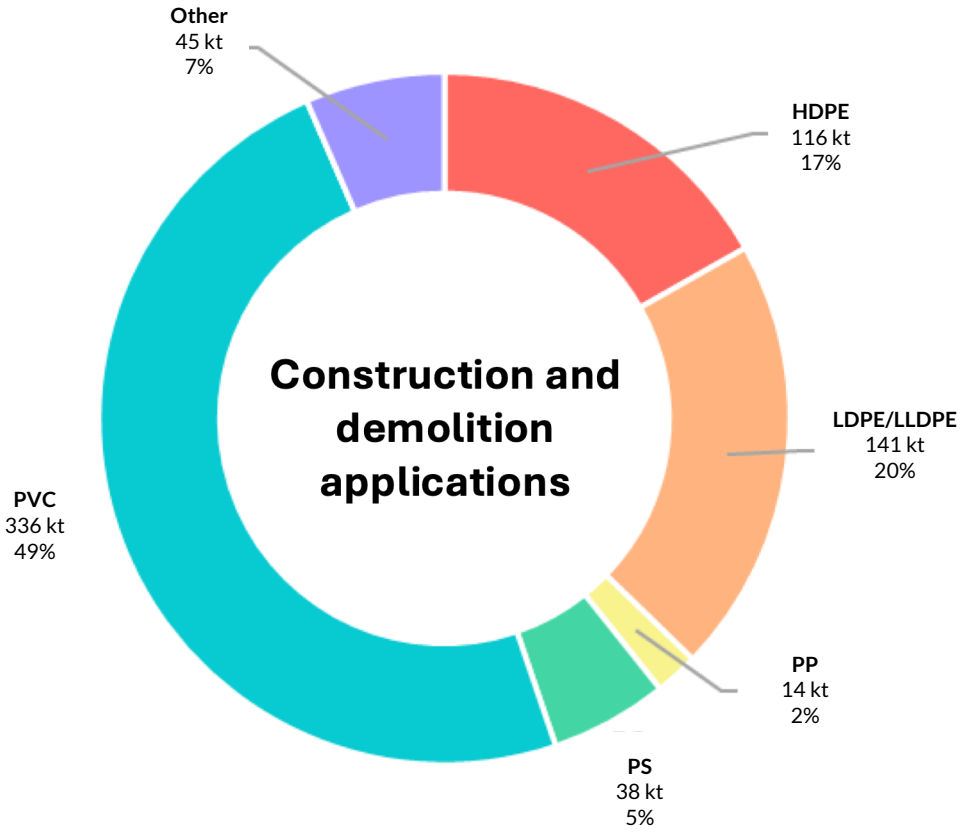
Figure 10. Types of resin in automotive sector uses, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Figure 11 shows the composition of resins used in construction and demolition. The most used resin is PVC with 336 kt (49 percent of the total), LDPE-L with 141 kt (20 percent of the total), HDPE with 116 kt (17 percent of the total), other resins with 45 kt (7 percent of the total), PS with 38 kt (5 percent of the total) and PP with 14 kt (2 percent of the total).

Figure 11. Resin types in construction and demolition uses, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

4.3 Domestic production of thermoplastic resins

Total production of thermoplastic resins (TP) in Mexico in 2022 was 3,508 kt. Of these, PET is the most produced TP resin in the country with 978 kt (28 percent of national production); in second place is PVC with 564 kt (16 percent of national production); in third place is HDPE with 500 kt (14 percent of national production); In fourth place is PP with 468 kt (13 percent of national production); in fifth place is PS with 388 kt (11 percent of national production); in sixth place is LDPE-L with 313 kt (9 percent of national production), and finally there are other TP resins, with 297 kt (8 percent of national production).

Table 10. TP resin production in Mexico, 2022 (kilotons)

Production	Abbreviation	kt	Percentage
1. Polyethylene Terephthalate	PET	978	28
2. High Density Polyethylene	HDPE	500	14
3. Polyvinyl Chloride	PVC	564	16
4. Low Density/Linear Polyethylene	LDPE/LLDPE	313	9
5. Polypropylene	PP	468	13
6. Polystyrene	PS	388	11
7. Other	Other	297	8
Total		**3.508**	**100**

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

4.4 Exports of thermoplastic resins

According to Table 11, in 2022 the most exported product was PET, with 368 kt exported (24 percent of the total). The second most exported product was PVA, with 347 kt (23 percent of the total). In third place came PS with 314 kt (20 percent of the total). This was followed by HDPE with 218 kt (14 percent of the total), LDPE-L with 137 kt (9 percent of the total), other TP resins with 113 kt (7 percent of the total) and, finally, PP with 43 kt (3 percent of the total).

Table 11. Exports of TP resins in Mexico, 2022 (kilotons)

Exports	Abbreviation	kt	Percentage
1. Polyethylene Terephthalate	PET	368	24
2. High Density Polyethylene	HDPE	218	14
3. Polyvinyl Chloride	PVC	347	23
4. Low Density/Linear Polyethylene	LDPE/LLDPE	137	9
5. Polypropylene	PP	43	3
6. Polystyrene	PS	314	20
7. Other	Other	113	7
Total		**1,540**	**100**

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

4.4.1 Imports of thermoplastic resins

Regarding imports of TP resins shown in Table 12, the main import was LDPE-L with 1,055 kt (22 percent of the total), followed by PP with 1,043 kt (22 percent of the total), other TP resins with 952 kt (20 percent of the total), HDPE with 833 kt (18 percent of the total), PVC with 403 kt (9 percent of the total), PS with 311 kt (7 percent of the total) and, finally, PET with 130 kt (3 percent of the total).

Table 12. Imports of TP resins, 2022 (kilotons)

Imports	Abbreviation	kt	Percentage
1. Polyethylene Terephthalate	PET	130	3
2. High Density Polyethylene	HDPE	833	18
3. Polyvinyl Chloride	PVC	403	9
4. Low Density/Linear Polyethylene	LDPE/LLDPE	1,055	22
5. Polypropylene	PP	1,043	22
6. Polystyrene	PS	311	7
7. Other	Other	952	20
Total		**4,727**	**100**

Source: Prepared by the authors with information from the ANIPAC 2023 *Statistical Yearbook*.

4.4.2 Apparent consumption

The above figures allow us to estimate the apparent consumption of materials in Mexico, which is calculated by considering the sum of domestic production plus imports minus exports. Total apparent consumption of TP resins in Mexico in 2022 was 6,695 kt. It was distributed according to resin type as follows: PP was the TP resin with the highest apparent consumption with 1,468 kt (22 percent), followed by LDPE-L with 1,231 kt (18 percent), that of other resins was 1,135 kt (17 percent), HDPE with 1,116 kt (17 percent), PET with 740 kt (11 percent), PVC with 620 kt (9 percent) and, finally, PS with 385 kt (6 percent).

In the Sankey diagram, these values are presented disaggregated in the nodes corresponding to each type of TP resin and then aggregated in the central waste generation node.

Table 13. Apparent TP consumption in Mexico, 2022 (kilotons)

Resin type	Abbreviation	kt	Percentage
1. Polyethylene Terephthalate	PET	740	11
2. High Density Polyethylene	HDPE	1,116	17
3. Polyvinyl Chloride	PVC	620	9
4. Low Density/Linear Polyethylene	LDPE/LLDPE	1,231	18
5. Polypropylene	PP	1,468	22
6. Polystyrene	PS	385	6
7. Other	Other	1,135	17
Total		**6,695**	**100**

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

4.4.3 Estimate of the amount of plastic waste per year and per capita in Mexico for 2022–2023

In this study, the calculation considered that the apparent consumption of TP resins in Mexico in 2022 equaled the generation of plastic waste. Based on figures from the 2020 Population and Housing Census, it was estimated that the country's population totaled 126,014,024 people (INEGI, 2020). Therefore, with apparent consumption data, the estimated waste generation during 2022 was 6,695 kt or 53 kilograms per inhabitant per year.

The values obtained from this study were compared with data from the National Inventory of Plastic Pollution Sources (2023) to check the consistency of the information. The Inventory estimated a per capita plastic waste range of 43 to 59 kilograms per year. On average, it is estimated that 51 kilograms of plastic waste is generated per inhabitant per year. Following this method, the population in Mexico in 2020 is multiplied by the average amount of waste per capita and the total waste generation per year is 6,427 kt. The difference between the two methods is two kilograms per inhabitant per year, or 268 kt in total per year. The difference is about 4 percent.

Similarly, the values of this study were compared with those obtained from the National Solid Waste Atlas prepared by INECC, where it is reported that the disposal of plastic waste is 18,286 tons per day (6,674 kt/year), as shown in Table 14.

This value considers PET, rubber, rigid and film plastic, expanded polystyrene, polyurethane and disposable diapers, waste whose composition includes plastics. Rubber, a polymer of natural origin, is not reported in this study because it is not a man-made synthetic polymer.

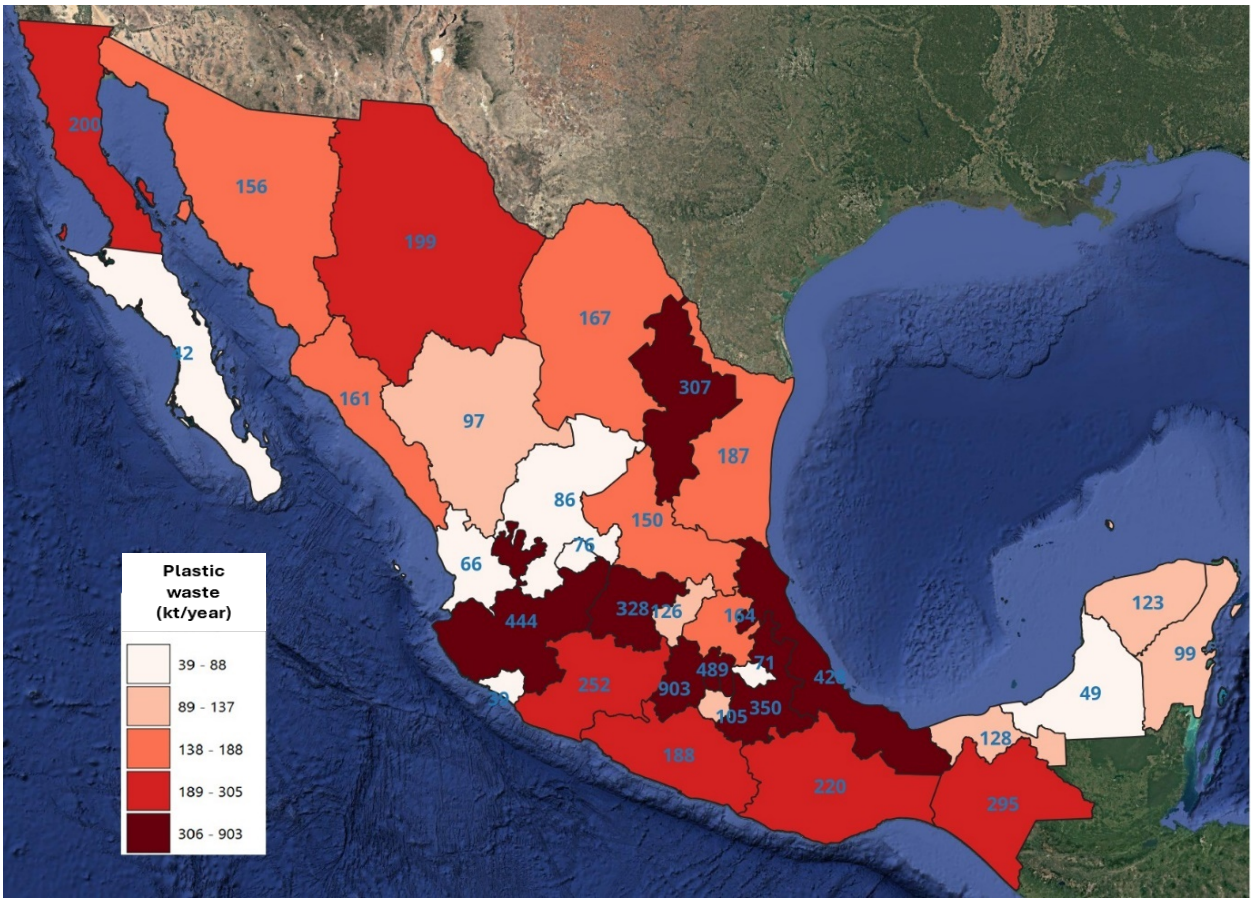
Table 14. Comparison of reported generation values in this study *vs.* National Inventory of Plastic Pollution Sources for 2022-2023

Parameters	Total	Unit
Población[1]	126,014,024	Persons
Per capita waste range[2]	43-59	Kg/inhab/yr
Average per capita waste from National Inventory[2]	51	Kg/inhab/yr
Total waste per year with Inventory method[2]	6,427	kt
Total waste per year with apparent consumption data[3]	6,695	kt
Average per capita waste from this study[3]	53.1	Kg/inhab/yr
Total waste per year from Atlas data[4]	6,674	kt
Atlas average per capita waste[4]	52.9	Kg/inhab/yr

Sources: 1: INEGI (2020). 2: National Inventory of Plastic Pollution Sources (2023). 3: ANIPAC (2023). 4: National Atlas of Municipal Solid Waste (2022).

The state distribution of plastic waste generated is shown in Figure 12, where the values are mapped from the application of the value of 53 kilograms per inhabitant per year and the population of each state, resulting in a distribution where the Estado de México, Mexico City, Jalisco, Veracruz, Puebla, Guanajuato, Nuevo León, Chiapas and Michoacán are the states that generate the largest amount of plastic waste (note that this index does not include socioeconomic activities).

Figure 12. Per capita generation of post-consumption plastic waste by federal state



Source: Prepared by the authors.

The states where the population is concentrated also coincide with high economic activity, except for Quintana Roo and Baja California Sur, whose high tourist activity and floating population determine a high generation of plastic waste without an industrial activity aimed at recycling.

Plastic generation values reported by INECC's 2022 National Solid Waste Atlas include PET, rubber, rigid and film plastic, expanded polystyrene, polyurethane and disposable diapers. Rubber, a naturally occurring polymer, was not included in this study.

Table 15. State generation of plastic waste reported in the National Atlas of Municipal Solid Waste, 2022 (tons/day)

State	Population	MSW generation t/d	MSW generation rate	Plastic generated t/d (1)
Aguascalientes	1,425,607	1,330	0.933	359
Baja California	3,769,020	3,535	0.938	VNR
Baja California Sur	798,447	737	0.923	169

State	Population	MSW generation t/d	MSW generation rate	Plastic generated t/d (1)
Campeche	928,363	1,330	1.433	97
Chiapas	5,543,828	4,964	0.895	730
Chihuahua	3,741,869	3,638	0.972	1,008
Mexico City	9,209,944	13,149	1.428	29
Coahuila	3,146,771	3,032	0.964	828
Colima	731,391	743	1.016	119
Durango	1,832,650	1,767	0.964	447
State of Mexico	16,992,418	16,739	0.985	2,856
Guanajuato	6,166,934	6,031	0.978	435
Guerrero	3,540,685	3,421	0.966	986
Hidalgo	3,082,841	2,649	0.859	395
Jalisco	8,348,151	7,961	0.954	1,242
Michoacán	4,748,846	4,459	0.939	1,021
Morelos	1,971,520	1,878	0.953	391
Nayarit	1,235,456	1,146	0.928	232
Nuevo León	5,784,442	5,310	0.918	VNR
Oaxaca	4,132,148	3,538	0.856	801
Puebla	6,583,278	5,991	0.910	575
Querétaro	2,368,467	2,085	0.880	352
Quintana Roo	1,857,985	1,546	0.832	90
San Luis Potosí	2,822,255	2,640	0.935	766
Sinaloa	3,026,943	3,068	1.014	VNR
Sonora	2,944,840	2,916	0.990	624
Tabasco	2,402,598	2,471	1.028	566
Tamaulipas	3,527,735	3,591	1.018	535
Tlaxcala	1,342,977	1,123	0.836	93
Veracruz	8,062,579	7,813	0.969	1,733
Yucatán	2,320,898	2,016	0.869	550
Zacatecas	1,622,138	1,505	0.928	256
Total	**126,014,024**			**18,286**

Source: Prepared by the authors with data from the National Solid Waste Atlas, INECC (2022).
Notes: 1: The value corresponds to the sum of PET, rubber, rigid plastics and films, expanded polystyrene, polyurethane and diapers. VNR stands for Value Not Reported.

4.5 Plastic waste value chain infrastructure

The description of the infrastructure for post-consumption and post-industrial plastic waste was organized based on the stages of the value chain: raw material and processing, recovery and recycling. This last stage, the most important for the secondary market, is where individual or collective services recover waste from the source of generation, mainly from large generators (industry, commerce or services) and where the material recovered from private individuals is bought and sold until it reaches the collection centers of large brands and the recycling industry. All of these generators have made commitments to the government and society to increase the recovery and recycling of their post-consumption waste, as does Ecoce (*Ecología y Compromiso Empresarial, A.C.*) on behalf of the soft drink and carbonated water industries.

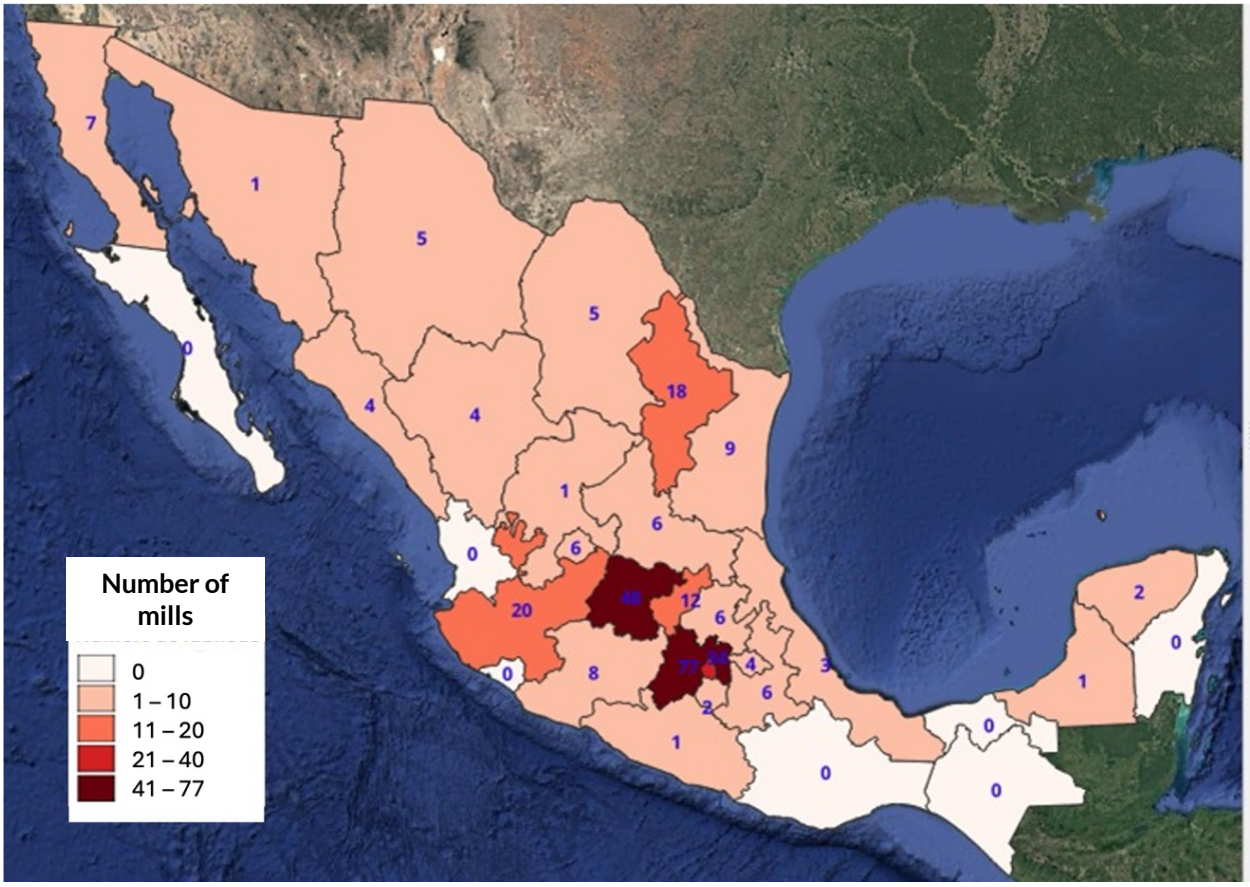
Infrastructure is directly related to the actors in the plastics value chain and their facilities, so this section is organized into the following groups:

- Raw materials infrastructure, including the production of virgin and recycled resins.
- Infrastructure for the processing and production of plastics.
- Infrastructure for the management of plastic waste, including both public and private infrastructure, with special attention to plastic collection centers.

4.5.1 Raw material infrastructure

The facilities that produce virgin raw materials were identified thanks to information from the National Statistical Directory of Economic Units (DENUE, 2024), which records the economic units dedicated to the manufacture of thermosets and thermoplastic synthetic resins in Mexico. There are currently 290 facilities in 25 states, with the State of Mexico, Guanajuato and Mexico City reporting more than 30 facilities, while in the southern and southeastern states of the country this economic activity does not appear (see Figure 13).

Figure 13. Number of facilities manufacturing virgin resins for plastics, by state



Source: Prepared by the authors with information from DENUE (2024).

The infrastructure for the production and recycling of virgin resins for plastics is located in 113 municipalities, with 290 factories. The municipalities with the largest number of establishments are León and San Francisco del Rincón, in Guanajuato, and Ecatepec, in Estado de México (see Table 16).

Table 16. Municipalities with more than two facilities for the manufacture of virgin resins

No.	State	Municipality	Population	No. of plants
1	Guanajuato	León	1,721,215	20
2	Guanajuato	San Francisco del Rincón	130,871	15
3	State of Mexico	Ecatepec	1,645,352	15
4	Mexico City	Benito Juárez	434,153	9
5	State of Mexico	Toluca	910,608	9

No.	State	Municipality	Population	No. of plants
6	Tamaulipas	Altamira	269,790	8
7	Mexico City	Iztapalapa	1,835,486	7
8	State of Mexico	Cuautitlán Izcalli	555,163	7
9	Jalisco	Guadalajara	1,385,629	6
10	San Luis Potosí	San Luis Potosí	911,908	6
11	Jalisco	Zapopan	1,476,491	5
12	State of Mexico	Tlalnepantla	672,202	5
13	Querétaro	El Marqués	231,668	5
14	Baja California	Tijuana	1,922,523	4
15	Mexico City	Cuauhtémoc	545,884	4
16	Mexico City	Azcapotzalco	432,205	4
17	Guanajuato	Silao	203,556	4
18	Guanajuato	Purísima del Rincón	83,842	4
19	Jalisco	Tonalá	569,913	4
20	State of Mexico	Atizapán	523,674	4
21	Michoacán	Morelia	849,053	4
22	Nuevo León	Monterrey	1,142,994	4
23	Nuevo León	Apodaca	656,464	4
24	Puebla	Puebla	1,692,181	4
25	Aguascalientes	Aguascalientes	948,990	3
26	Coahuila	Torreón	720,848	3
27	Chihuahua	Juárez	1,512,450	3
28	Mexico City	Iztacalco	404,695	3
29	Mexico City	Miguel Hidalgo	414,470	3
30	Durango	Durango	688,697	3
31	Jalisco	Tlajomulco	727,750	3
32	State of Mexico	Ocoyoacac	72,103	3
33	State of Mexico	Tultitlán	516,341	3
34	State of Mexico	Tepotzotlán	103,696	3
35	Nuevo León	Santa Catarina	306,322	3
36	Querétaro	San Juan del Río	297,804	3
37	Querétaro	Querétaro	1,049,777	3

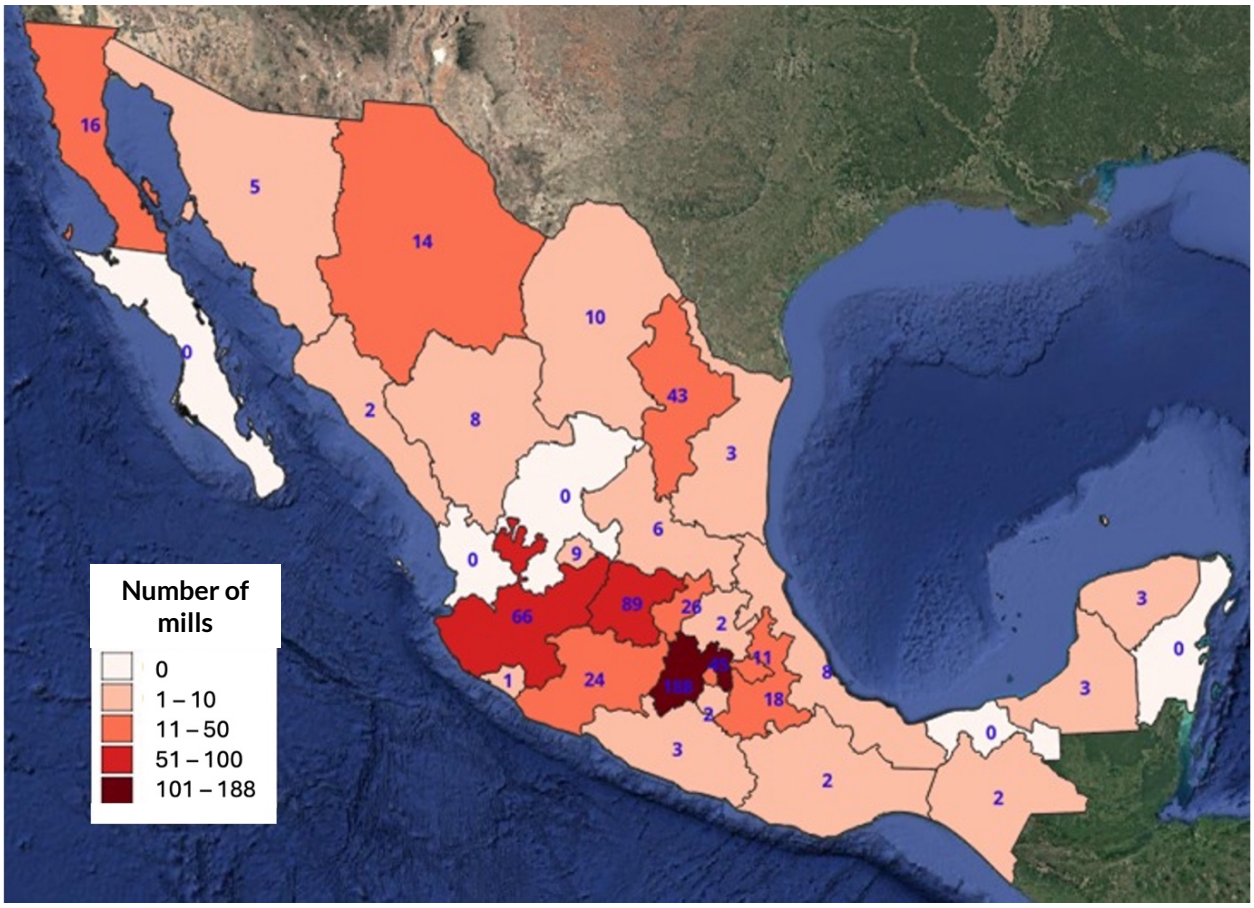
No.	State	Municipality	Population	No. of plants
38	Sinaloa	Culiacán	1,003,530	3
39	Aguascalientes	Jesús María	129,929	2
40	Baja California	Ensenada	443,807	2
41	Mexico City	Gustavo A. Madero	1,173,351	2
42	Guanajuato	San José Iturbide	89,558	2
43	Hidalgo	Tizayuca	168,302	2
44	State of Mexico	Cuautitlán	178,847	2
45	State of Mexico	Nezahualcóyotl	1,077,208	2
46	State of Mexico	Ixtapaluca	542,211	2
47	State of Mexico	Tecámac	547,503	2
48	Michoacán	Zacapu	76,829	2
49	Puebla	Cuautlancingo	137,435	2
50	Tlaxcala	Xicohtzinco	14,197	2

Source: Prepared by the authors, with information from DENUE (2024).

Information on facilities using recycled resins to manufacture plastic products comes from DENUE (2024). In Mexico there are 609 facilities in 27 states, numbers that indicate the dynamics of plastic recycling throughout the country. Most of these factories are small, with about five employees.

The states with more than 40 recycled resin production facilities are Estado de México, Guanajuato, Jalisco, Mexico City and Nuevo León. Figure 14 (below) shows that most of the recycled resin production activity takes place in the center of the country.

Figure 14. Number of facilities manufacturing recycled resins for plastics by federal state



Source: Prepared by the authors with information from DENUE (2024).

DENUE 2024 reveals 609 recycled resin producing factories, located in 166 municipalities, with León, Guanajuato; Ecatepec and Toluca, Estado de México, and Iztapalapa, Mexico City, as those with the highest number of these facilities in their territory (see Table 17).

Table 17. Municipalities with more than four recycled resin factories for plastics

No.	State	Municipality	Population	No. of plants
1	Guanajuato	León	1,721,215	57
2	State of Mexico	Ecatepec	1,645,352	35
3	Mexico City	Iztapalapa	1,835,486	23
4	State of Mexico	Toluca	910,608	19
5	Jalisco	Guadalajara	1,385,629	15
6	Jalisco	San Pedro Tlaquepaque	687,127	14
7	State of Mexico	Acolman	171,507	14

No.	State	Municipality	Population	No. of plants
8	Nuevo León	Monterrey	1,142,994	13
9	Querétaro	El Marqués	231,668	12
10	Jalisco	Tonalá	569,913	11
11	State of Mexico	Nezahualcóyotl	1,077,208	11
12	State of Mexico	Cuautitlán Izcalli	555,163	11
13	Baja California	Tijuana	1,922,523	10
14	Jalisco	El Salto	232,852	10
15	State of Mexico	Tultitlán	516,341	10
16	Nuevo León	Apodaca	656,464	10
17	Chihuahua	Juárez	1,512,450	9
18	State of Mexico	Atizapán	523,674	9
19	Mexico City	Tláhuac	392,313	8
20	Guanajuato	San Francisco del Rincón	130,871	8
21	Querétaro	Querétaro	1,049,777	8
22	Guanajuato	Apaseo el Grande	117,883	7
23	State of Mexico	Zumpango	280,455	7
24	State of Mexico	Tecámac	547,503	7
25	Michoacán	Morelia	849,053	7
26	Durango	Gómez Palacio	372,750	6
27	State of Mexico	Chalco	400,057	6
28	State of Mexico	La Paz	304,088	6
29	Nuevo León	General Escobedo	481,213	6
30	San Luis Potosí	San Luis Potosí	911,908	6
31	Baja California	Tecate	108,440	5
32	Chihuahua	Chihuahua	937,674	5
33	Michoacán	Zacapu	76,829	5
34	Puebla	Puebla	1,692,181	5

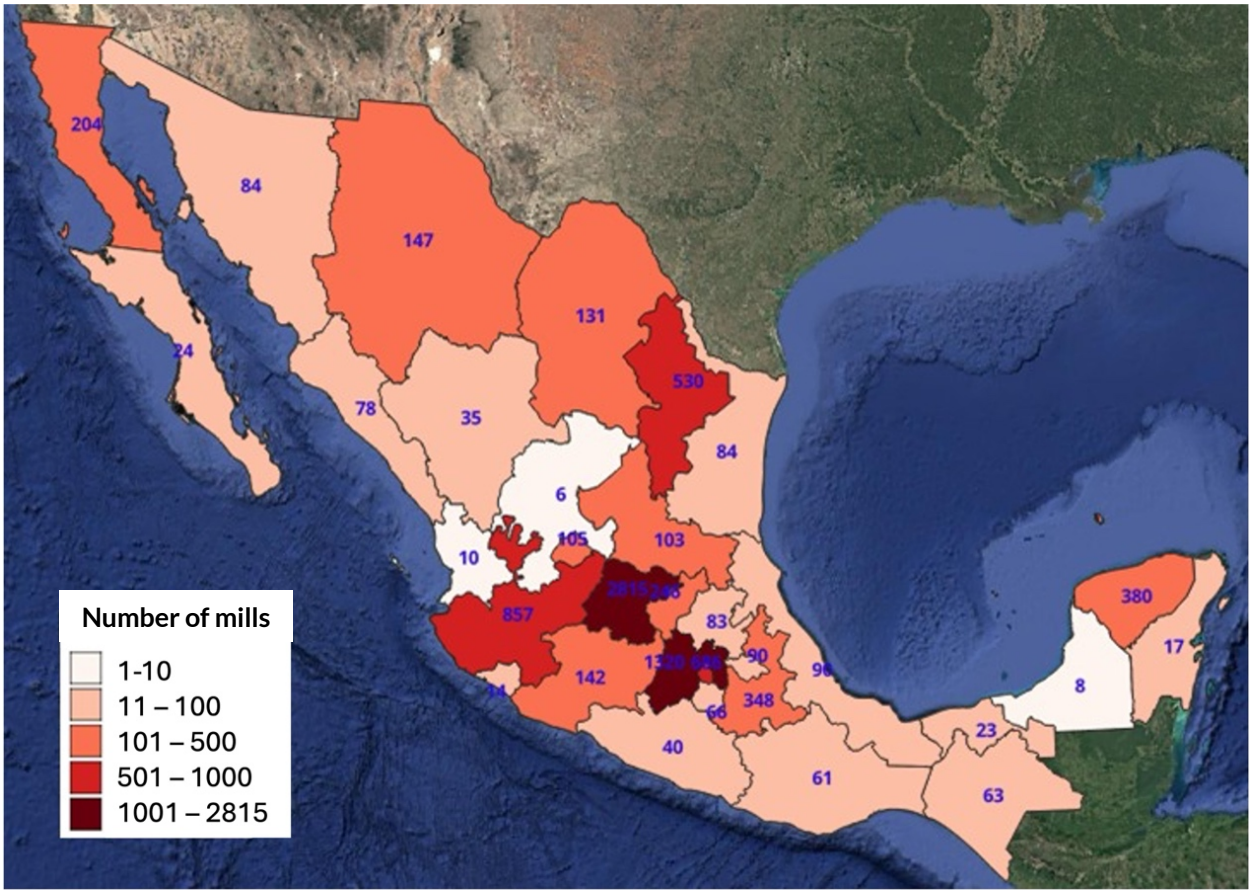
Source: Prepared by the authors, with information from DENUE (2024).

4.5.2 Plastics processing and production infrastructure

The plastic products industry in Mexico is very diverse in terms of quantity and diversity of manufactures. Particularly noteworthy are the numerous companies that transform both virgin and recycled resins into a wide range of plastic articles for everyday use.

With information from DENUE (2024), the facilities that transform virgin and recycled plastic resins in Mexico were identified and located. Specifically, 8,890 facilities were reported throughout the country, where the states with more than 500 facilities in their territory are Guanajuato, Estado de México, Jalisco, Mexico City and Nuevo León (see Figure 15).

Figure 15. Number of facilities that manufacture plastic products by federal state

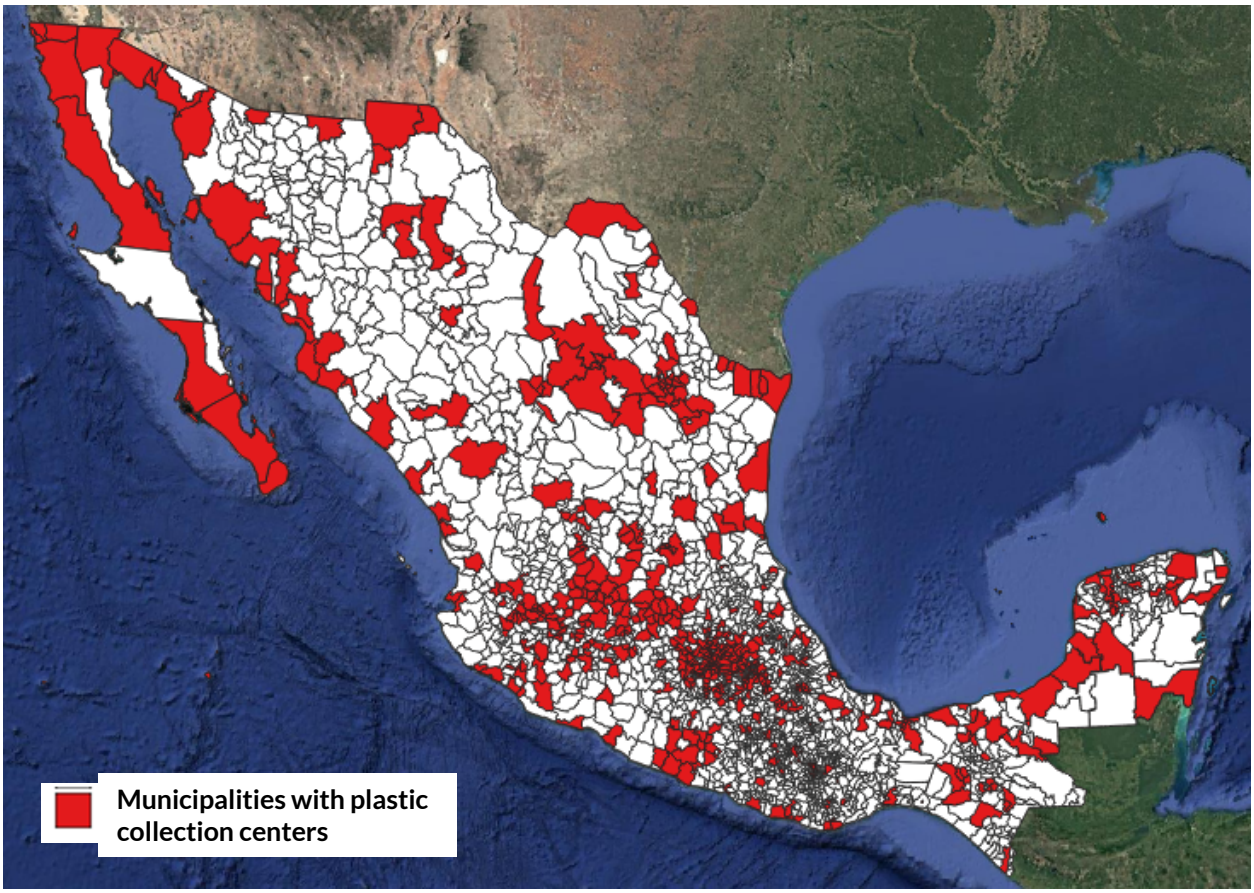


Source: Prepared by the authors with information from DENUE (2024).

It can also be observed that the production of plastic products is concentrated in the central and northeastern states of the country. Distribution centers play a key role in getting products to all states.

Plastic product factories are in 587 municipalities in all states of the country (see Figure 16).

Figure 16. Distribution of plastic product factories by municipality



Source: Prepared by the authors, with information from DENUE (2024).

The municipalities with the most factories are León, San Francisco del Rincón and Purísima del Rincón, Guanajuato; Guadalajara, Jalisco; and Toluca, Estado de México (see Table 18), and many of the factories in the state of Guanajuato are engaged in the production of plastic footwear.

Table 18. Municipalities with more than 100 factories producing plastic products in their territory

No.	State	Municipality	Population	No. of factories
1	Guanajuato	León	1,721,215	1,241
2	Guanajuato	San Francisco del Rincón	130,871	855
3	Guanajuato	Purísima del Rincón	83,842	591
4	Jalisco	Guadalajara	1,385,629	378

No.	State	Municipality	Population	No. of factories
5	State of Mexico	Toluca	910,608	278
6	Yucatán	Ticul	40,495	241
7	Mexico City	Iztapalapa	1,835,486	223
8	Jalisco	Zapopan	1,476,491	173
9	State of Mexico	Ecatepec	1,645,352	168
10	Nuevo León	Monterrey	1,142,994	149
11	Baja California	Tijuana	1,922,523	129
12	Querétaro	Querétaro	1,049,777	114
13	Nuevo León	Apodaca	656,464	101

Source: Prepared by the authors, with information from DENUE (2024).

According to the above data, the need for plastic materials is present in all states of the country, mainly in the central, northeastern and southeastern regions of the territory, so the plastic recovery infrastructure has a close geographic correlation with this industry.

The recovery of post-consumption plastic waste is better and more efficient when it occurs close to the source of generation, complemented by good transportation logistics that enable the flow of waste throughout the national territory. All the large companies in the beverage and carbonated water sector, as well as those in the food packaging sector, have a network of collectors in the country that supply them with material, and the determining factor in whether or not to buy waste, regardless of the point of origin, is price.

4.5.3 Public and private infrastructure for plastics waste management

In Mexico, the management and handling of municipal solid waste (MSW) corresponds to the municipal level, and that of special handling waste (SHW) to the state level; however, the collection and handling of both is mainly handled by municipal or private services. Therefore, plastic recycling is promoted through the generation of public or private intermunicipal infrastructure and economic and social policies for the use of waste from the municipality, supported by federal and state regulations and with the full involvement of the private sector for the creation of recycling infrastructure. The population is responsible for complying with the legislation and using the available infrastructure, both public and private.

This infrastructure for integrated waste management, and in particular for waste recovery, is different in each of the country's states. Knowing the number of facilities and the population they serve are indicators that allow us to know what the operation and infrastructure of the state is like, but it does not help to determine the quality of the services, the efficiency of waste collection, nor the impact of this infrastructure and services on the environment, on the quality of the air, soil, subsoil and water, nor the presence or absence of waste in the environment.

The available public infrastructure, despite being facilities designed for residual recovery, only operates for waste transfer. In many cases, sorting plants have equipment in poor condition, so that waste sorting efficiency is less than 10 percent, all related to technologies, operating conditions and the impact of waste pre-sorting on collection vehicles and the chain of collection centers.

In general, Mexico does not have differentiated on-street collection systems that allow it to recover plastic at the source. The strategies, goals and actions of companies to recover post-consumption and post-industrial plastic waste are defined by the participation of the private sector and their management plans.

Plastic recovery schemes by public, private, formal and informal actors, which reintegrate the material into the value chain, only manage waste with economic value for the industry, such as PET, PP, PS, HDPE, LDPE bottles, although the operation is extended to other applications, such as packaging, trays, domes and hinges, made from these materials in the food sector and where it is common practice for waste to be used in the manufacture of new products. In this process, it should be clarified, there is a general rejection of the use of plastics from other applications because they contain chemicals that include antistatic products or flame retardants.

This is why collection centers, the most important private infrastructure to be considered in the recovery of plastic waste, are the focal point where the products of all types of garbage pickers, as well as the public and, in some cases, large generators, are concentrated. They are the ones who sell or supply post-consumption waste to the production and recycling industries.

All the facilities are part of the service that the government and the private sector provide to the population for the recovery of post-consumption waste to be recycled and reintegrated into the value chain. In this area, the highest recovery values correspond to the private sector, which has the technology and facilities necessary for the recycling of post-consumption and post-industrial waste, and the recovery of containers, packaging and packing and, in minimal quantities, products such as cutlery, straws, plates, bags and other products now identified as single-use plastics. These, it should be said, represent the greatest interest of the garbage pickers because of the lower effort in their recovery, i.e., the number of units per kilogram and the transaction value per kilogram recovered.

Mexico's plastics waste management infrastructure is shown in Tables 19 and 20.

Table 19. Public and private infrastructure involved in waste management by state

State	Population	Plastic waste collection centers (1)	Collection vehicles (2)	Transfer stations (2)
Aguascalientes	1,425,607	45	186	5
Baja California	3,769,020	27	529	6
Baja California Sur	798,447	6	186	0

State	Population	Plastic waste collection centers (1)	Collection vehicles (2)	Transfer stations (2)
Campeche	928,363	10	55	0
Coahuila	3,146,771	47	303	9
Colima	731,391	7	84	1
Chiapas	5,543,828	65	430	5
Chihuahua	3,741,869	34	457	3
Mexico City	9,209,944	297	2,740	12
Durango	1,832,650	36	182	1
State of Mexico	16,992,418	887	2,257	19
Guanajuato	6,166,934	230	557	0
Guerrero	3,540,685	45	361	0
Hidalgo	3,082,841	59	361	7
Jalisco	8,348,151	193	1,287	11
Michoacán	4,748,846	120	867	2
Morelos	1,971,520	71	262	5
Nayarit	1,235,456	16	131	0
Nuevo León	5,784,442	139	456	5
Oaxaca	4,132,148	82	1,038	12
Puebla	6,583,278	239	560	2
Querétaro	2,368,467	48	237	2
Quintana Roo	1,857,985	7	199	2
San Luis Potosí	2,822,255	37	806	3
Sinaloa	3,026,943	16	291	0
Sonora	2,944,840	38	346	2
Tabasco	2,402,598	13	324	1
Tamaulipas	3,527,735	17	448	6
Tlaxcala	1,342,977	59	176	0
Veracruz	8,062,579	124	917	9
Yucatán	2,320,898	64	314	1
Zacatecas	1,622,138	18	246	1

Source: Prepared by the authors with information from: (1) National Census of Municipal Governments (2023); (2) National Statistical Directory of Economic Units (2024), and (3) National Institute of Ecology and Climate Change (2022).

Table 20. Public and private infrastructure involved in waste management by state (*continued*)

State	Treatment plants (1)	Final disposal sites (2)	Sanitary landfills (3)
Auascalientes	0	2	1
Baja California	0	20	2
Baja California Sur	0	32	0
Campeche	0	12	2
Coahuila	0	41	6
Colima	0	3	1
Chiapas	2	125	0
Chihuahua	1	164	2
Mexico City	2	0	0
Durango	0	61	1
State of Mexico	4	63	13
Guanajuato	1	43	5
Guerrero	0	133	1
Hidalgo	3	52	4
Jalisco	13	123	12
Michoacán	4	112	4
Morelos	0	15	2
Nayarit	1	29	1
Nuevo León	2	42	3
Oaxaca	2	432	0
Puebla	2	95	10
Querétaro	1	12	5
Quintana Roo	1	28	3
San Luis Potosí	0	59	2
Sinaloa	0	48	1
Sonora	0	116	2
Tabasco	2	17	1
Tamaulipas	1	41	3
Tlaxcala	1	4	1
Veracruz	4	108	3
Yucatán	1	126	1
Zacatecas	0	92	1

Source: Prepared by the authors with information from: (1) National Census of Municipal Governments (2023); (2) National Statistical Directory of Economic Units (2024), and (3) National Institute of Ecology and Climate Change (2022).

With the information in the previous tables, Table 21 was prepared, which presents the number of facilities per 100,000 inhabitants in each state, in addition to the percentage of coverage of public services and a column with the percentage of final disposal sites that are sanitary landfills. The objective was to be able to compare the infrastructure of the different states according to their population.

The values in the last column are important because they provide context to the values reported by the various sources of information, so that the reader can identify how many of the waste disposal sites are sanitary landfills and, therefore, sites whose adequate waste control, in accordance with NOM-083-Semarnat-2003, reduces environmental impact.

Table 21. Coverage of solid waste collection and management facilities per 100,000 inhabitants and percentage of sanitary landfills in the states

State	Collection coverage (%) (1)	Plastic collection centers (2)	Collection vehicles (1)	Transfer stations (1)	Treatment plants (1)	Final disposal sites (1)	FDS that are sanitary landfills (%) (3)
Aguascalientes	71	3.21	13.29	0.36	0.00	0.14	50
Baja California	84	0.71	13.92	0.16	0.00	0.53	10
Baja California Sur	100	0.75	23.25	0.00	0.00	4.00	0
Campeche	89	1.11	6.11	0.00	0.00	1.33	17
Coahuila	75	1.52	9.77	0.29	0.00	1.32	15
Colima	100	1.00	12.00	0.14	0.00	0.43	33
Chiapas	58	1.18	7.82	0.09	0.04	2.27	0
Chihuahua	96	0.92	12.35	0.08	0.03	4.43	1
Mexico City	100	3.23	29.78	0.13	0.02	0.00	
Durango	75	2.00	10.11	0.06	0.00	3.39	2
State of Mexico	74 5.22	13.28 0.11	0.02	0.37	21		
Guanajuato	69	3.71	8.98	0.00	0.02	0.69	12
Guerrero	78	1.29	10.31	0.00	0.00	3.80	1
Hidalgo	79	1.90	11.65	0.23	0.10	1.68	8
Jalisco	94	2.33	15.51	0.13	0.16	1.48	10
Michoacán	100	2.55	18.45	0.04	0.09	2.38	4
Morelos	78	3.55	13.10	0.25	0.00	0.75	13
Nayarit	100	1.33	10.92	0.00	0.08	2.42	3

State	Collection coverage (%) (1)	Plastic collection centers (2)	Collection vehicles (1)	Transfer stations (1)	Treatment plants (1)	Final disposal sites (1)	FDS that are sanitary landfills (%) (3)
Nuevo León	86	2.40	7.86	0.09	0.03	0.72	7
Oaxaca	56	2.00	25.32	0.29	0.05	10.54	0
Puebla	70	3.62	8.48	0.03	0.03	1.44	11
Querétaro	90	2.00	9.88	0.08	0.04	0.50	42
Quintana Roo	100	0.37	10.47	0.11	0.05	1.47	11
San Luis Potosí	71	1.32	28.79	0.11	0.00	2.11	3
Sinaloa	100	0.53	9.70	0.00	0.00	1.60	2
Sonora	85	1.31	11.93	0.07	0.00	4.00	2
Tabasco	81	0.54	13.50	0.04	0.08	0.71	6
Tamaulipas	85	0.49	12.80	0.00	0.03	1.17	7
Tlaxcala	94	4.54	13.54	0.00	0.08	0.31	25
Veracruz	78	1.53	11.32	0.11	0.05	1.33	3
Yucatán	74	2.78	13.65	0.04	0.04	5.48	1
Zacatecas	71	1.13	15.38	0.06	0.00	5.75	1

Source: Prepared by the authors with information from: (1) National Census of Municipal Governments (2023); (2) National Statistical Directory of Economic Units (2024), and (3) National Institute of Ecology and Climate Change (2022).
Note: The states with the highest values for each parameter are shown in green, and those with the lowest values are shown in red.

Clearly, the larger the population, the more infrastructure is required for waste management and recovery. However, a large number of collection facilities or units (or a smaller number of them) does not necessarily translate into good or bad management of the waste generated by the population. An example of this is Mexico City, which does not have a SLF, CSi or UCSi; however, its 2023 Solid Waste Inventory indicates that the disposal of more than 12,000 tons per day occupies a SLF that complies with the regulations that apply in other states.

On the other hand, there are states that report a large amount of FDS, from which adequate management could be expected. This is the case of Oaxaca, yet this state has no sanitary landfills, and its 380 facilities, mostly UCSi and CSi, offer limited environmental protection, as they affect the air, soil and water, as well as the environment.

There are eight states in the country that have more than 100 facilities for the final disposal of waste, namely: Chiapas, Chihuahua, Guerrero, Jalisco, Sonora, Veracruz, Yucatán and Oaxaca (INECC, 2022).

Plastic waste recovery is usually carried out at sites classified as CSi and UCSi. This activity is carried out under precarious conditions and the material recovered is generally contaminated with other waste, and in some cases it is highly weathered.

In general, the plastic materials recovered for recycling are sold to larger collectors located in the vicinity of the extraction site. This is done through a direct transaction and ends up in the facilities of the plastic processing and production industry itself or in the recycling industry.

Recycling in Mexico, which is mainly carried out by the private sector, takes place in a material or thermal manner, as is the case in the cement industry. It is important to point out that the country does not have a single incineration or thermal treatment facility for obtaining electricity from municipal solid waste or special handling waste.

Plastic recovery is carried out in different ways:

- At the source, through specific containers installed on public roads.
- For collection and separation, by private and public collection service providers.
- Garbage pickers, who obtain the material at the source of generation: household, trade and services and FDS.
- MSW and SHW sorting plants.
- By the population, which delivers its waste to collection centers.
- For importation of plastics.

As a complement to the waste collection by state presented in Table 21, to analyze the coverage of MSW collection services in Mexico, data from the 2023 National Census of Municipal Governments (CNGM) and Territorial Districts of Mexico City were used. The census information covers the period from 1 January 2022 to 31 December 2022 and includes 2,475 municipalities, 49 of which were excluded due to incomplete records.

Of the registered municipalities, 150 (6 percent of the total) do not have MSW collection services, which is serious considering that the National Population Council reports that 600,363 people live in these municipalities.

Regarding the type of population that inhabits these municipalities, the National Commission for the Development of Indigenous Peoples classifies a municipality as Indigenous by the identification of the Indigenous household, which is the one where the head of household, his/her spouse or any of the ascendants declared to be a speaker of an Indigenous language, and by the quantification of the population based on the total number of its members. This definition generates two categories:

- Indigenous municipalities A. Where its Indigenous population equals or exceeds 70 percent of the total population.
- Indigenous municipalities B. Where its Indigenous population ranges from 40 percent to 69.9 percent of the total population.

In 2022, 615 municipalities considered Indigenous responded to the census questionnaire: 440 (73 percent) of type A and 165 (27 percent) of type B. A total of 9,588,871 people live in municipalities considered Indigenous: 5,721,770 people live in Indigenous municipalities A (60 percent of the total), and 3,867,101 people live in Indigenous municipalities B (40 percent of the total).

Of these municipalities, Oaxaca has the highest percentage of people without collection services (64.5 percent of all municipalities), followed by Veracruz with 12.56 percent and Puebla with 7.41 percent.

Among the municipalities without access to MSW collection services, 86 are considered Indigenous (57 percent of the municipalities) and 64 are considered non-Indigenous (43 percent). Among municipalities without MSW collection services, it is 1.34 times more likely to be an Indigenous municipality. Of the total number of non-Indigenous municipalities that responded to the questionnaire (1,811), 64 (3.53 percent) do not have municipal solid waste collection services.

Among all the municipalities in the country that responded to the questionnaire, a municipality with an Indigenous population A is almost four times more likely to have no access to MSW collection services compared to a municipality with an Indigenous population B.

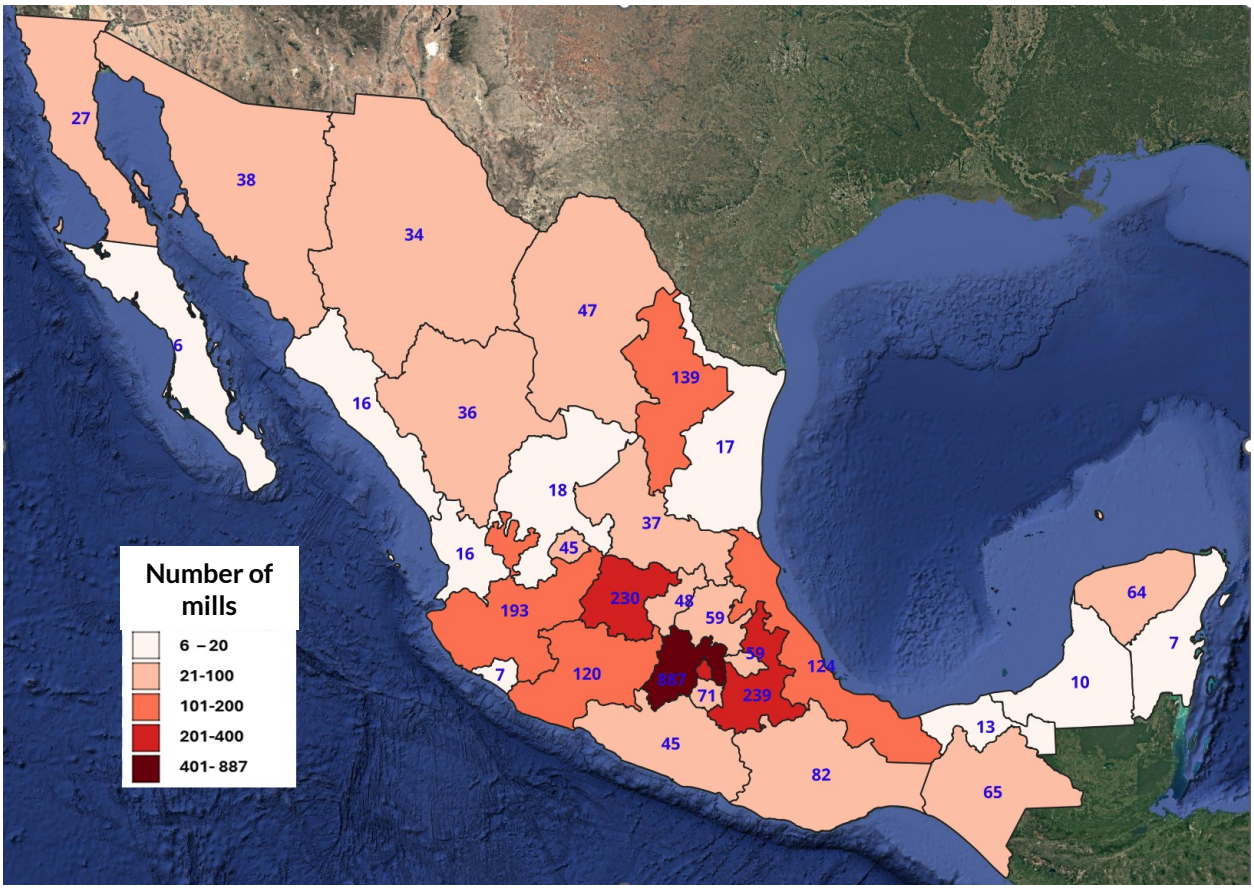
It is important to mention that municipalities without collection services do not have other waste management infrastructure either, so waste is burned, buried or deposited in local dumps that are not controlled.

Plastic waste collection centers

As mentioned, collection centers are key to waste management. According to DENUE (2024), in Mexico there are 3,095 centers of this type in 509 municipalities, all dedicated to the recovery of plastic waste. The states with the largest number of collection centers are Estado de México, Mexico City, Puebla, Guanajuato, Jalisco, Nuevo León, Veracruz and Michoacán, all with more than 100 collection centers in their territory (see Figure 17).

There are regions with very few facilities, such as the southern region (Oaxaca, Chiapas and Guerrero), where the material arrives in collection vehicles after the difficulties caused by poor road conditions, the distance between localities and the amount of waste generated.

Figure 17. Quantity and distribution of plastic waste collection centers by state



Source: Prepared by the authors, with information from DENUE (2024).

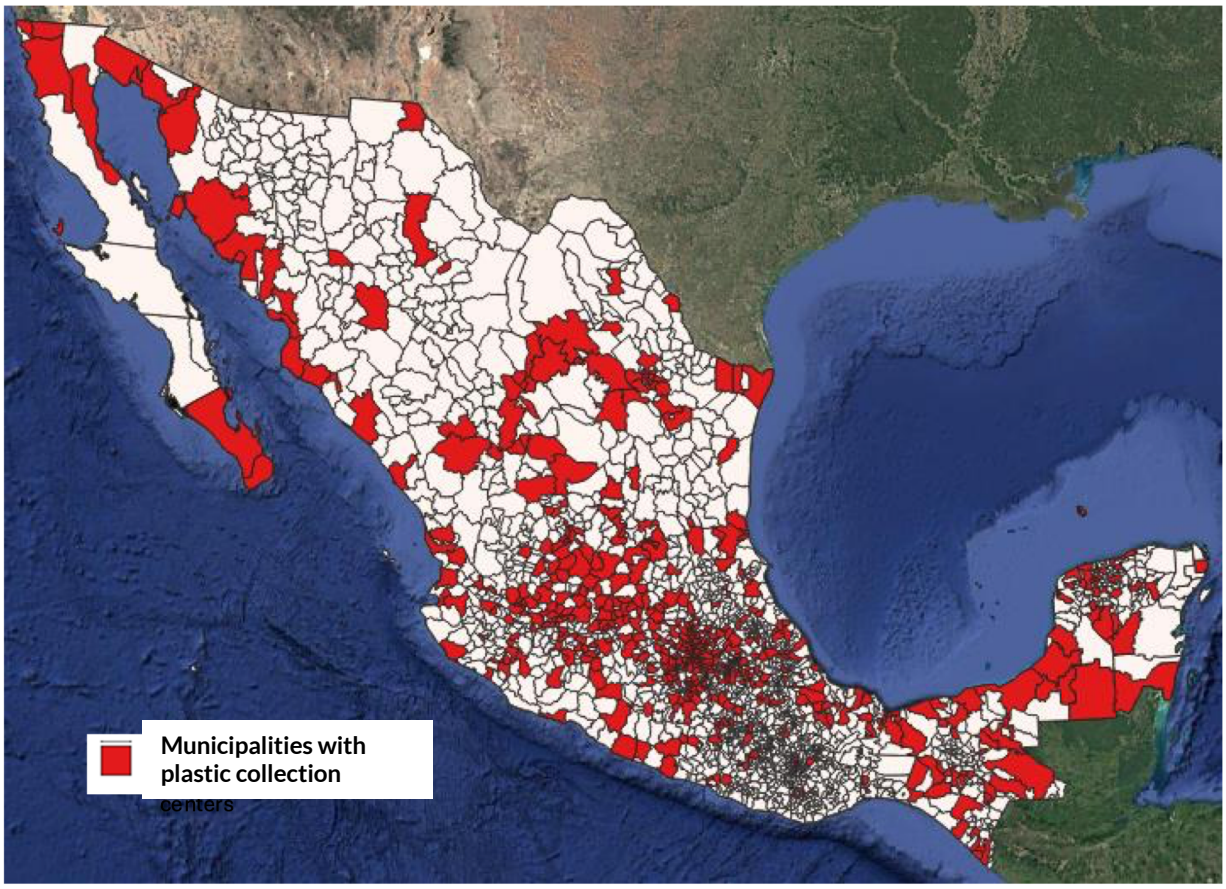
Table 22 shows that the Estado de México and Mexico City are the states with the highest number of plastic CCs per 100,000 inhabitants, while Quintana Roo and Tamaulipas have the lowest values. Thus, the concentration of CC coverage per 100,000 inhabitants is high in the central states of the country, while states such as Campeche, Quintana Roo, Colima and Baja California Sur have very few collection centers, despite their significant economic activities, such as tourism, which generate considerable amounts of waste that can be recycled (Semarnat, 2023) (see Figure 18).

The location of the collection centers responds to the areas where plastic waste is generated, the presence of waste buying and selling networks or the location of the recycling industry, although industrial recycling plants can transport waste from any part of the country, as long as it is financially convenient for them.

Such is the case of PET in bottles. Through organizations such as the civil association Ecoce, waste is recovered in collection centers throughout the country and then sent to facilities such as PetStar, in Estado de México, and other plastic manufacturing and recycling companies such as ALPLA, Planeta, Indorama, Inplarsa, Alcamare, Braskem Idesa and Inix. These companies market the waste

regardless of the origin, distance or location from where it is recovered, inside or outside the country.

Figure 18. Municipalities where plastic collection centers are located



Source: Prepared by the authors, with information from DENUE (2024).

The municipalities with the most CCs in their territory are Ecatepec and Chimalhuacán, Estado de México; Iztapalapa, Mexico City; León, Guanajuato; and Puebla, Puebla (see Table 22). The largest number of municipalities with this type of facility are located in Estado de México.

Table 22. Municipalities with more than 20 plastic waste collection centers

No.	State	Municipality	Population	CC Number
1	State of Mexico	Ecatepec	1,645,352	162
2	Mexico City	Iztapalapa	1,835,486	155
3	Guanajuato	León	1,721,215	105
4	Puebla	Puebla	1,692,181	84
5	State of Mexico	Chimalhuacán	705,193	73

No.	State	Municipality	Population	CC Number
6	State of Mexico	Nezahualcóyotl	1,077,208	58
7	State of Mexico	Toluca	910,608	54
8	State of Mexico	Tultitlán	516,341	46
9	State of Mexico	Ixtapaluca	542,211	44
10	Jalisco	San Pedro Tlaquepaque	687,127	37
11	State of Mexico	Atizapán	523,674	35
12	State of Mexico	La Paz	304,088	35
13	Aguascalientes	Aguascalientes	948,990	34
14	Jalisco	Guadalajara	1,385,629	33
15	Nuevo León	Monterrey	1,142,994	32
16	Oaxaca	Villa de Zaachila	46,464	29
17	Mexico City	Gustavo A. Madero	1,173,351	27
18	State of Mexico	Valle de Chalco Solidaridad	391,731	27
19	Coahuila	Torreón	720,848	26
20	State of Mexico	Chalco	400,057	26
21	State of Mexico	Naucalpan	834,434	25
22	Nuevo León	General Escobedo	481,213	25
23	Mexico City	Tláhuac	392,313	24
24	Guanajuato	Irapuato	592,953	23
25	Jalisco	Zapopan	1,476,491	23
26	State of Mexico	Tlalnepantla	672,202	23
27	Yucatán	Mérida	995,129	22

Source: Prepared by the authors, with information from DENUE (2024).

Installing an CC close to the source of generation facilitates the recycling market and integrates more people into the activity, but it also increases the price of the material and maintains a poor and exploited social structure. It also solves some organizational and connectivity problems.

In the country, there are municipalities in which the potential for plastic waste recovery would be expected to be high due to their more than 500,000 inhabitants; however, for now they are districts with very few collection centers; this is the case of:

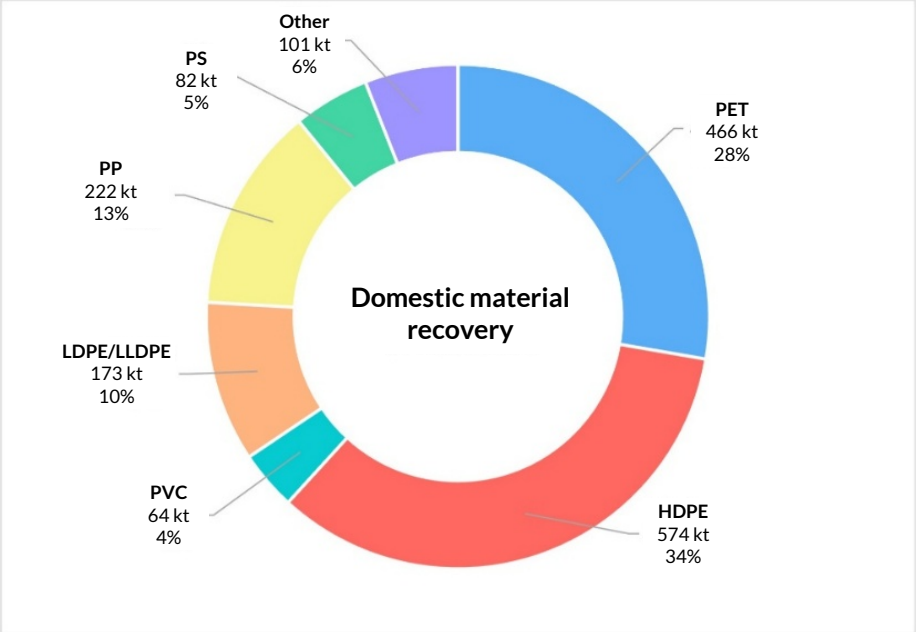
- Mexicali, Baja California (no CCs)
- Reynosa, Tamaulipas (two)
- Benito Juárez, Quintana Roo (tres)
- Centro, Tabasco (three)
- Matamoros, Tamaulipas (three)
- Culiacán, Sinaloa (four)

- Saltillo, Coahuila (five)

5. Secondary Markets

ANIPAC estimated that in 2022 the volume of plastic waste recovered for recycling in the country was 1,683 kt, implying a recovery rate of 25 percent. HDPE is the most recovered material with 574 kt (34 percent of total), followed by PET with 466 kt (28 percent of total), PP with 222 kt (13 percent of total), LDPE-L with 173 kt (10 percent of total), other resins with 101 kt (6 percent of total), PS with 82 kt (5 percent of total) and PVC with 64 kt (4 percent of total) (see Figure 19 and Table 23).

Figure 19. Domestic recovery of plastic materials, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

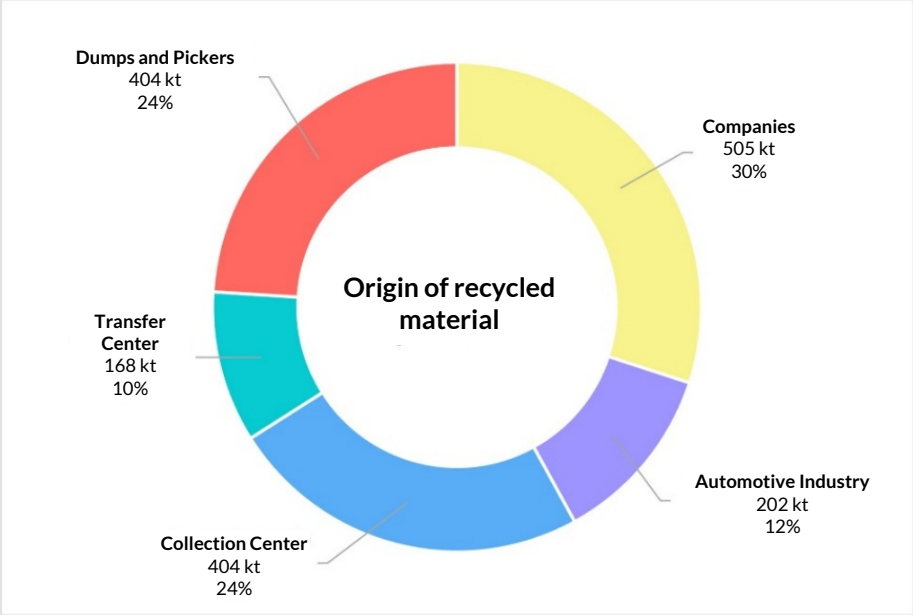
Table 23. Recovery of materials for recycling in Mexico, 2022 (kilotons)

Recovery of materials	Abbreviation	kt	Percentage
1. Polyethylene terephthalate	PET	466	28
2. High Density polyethylene	HDPE	574	34
3. Polyvinyl chloride	PVC	64	4
4. Low Density/Linear polyethylene	LDPE/LLDPE	173	10
5. Polypropylene	PP	222	13
6. Polystyrene	PS	82	5
7. Other	–	101	6
Total		**1,683**	**100**

Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Figure 20 shows the amount and origin of domestically sourced material recycled in 2022. The main source is companies, with 505 kt (30 percent of the total), followed by collection centers with 404 kt (24 percent of the total), dumps and gathering sites with 404 kt (24 percent of the total), the automotive industry with 202 kt (12 percent of the total) and transfer centers with 168 kt (10 percent of the total). It should be mentioned that materials from industry and the automotive sector are cleaner compared to those from the other sources mentioned above. However, it is important to consider that the applications restrict the use of recovered material, which means that any plastics impregnated with flame retardants or antistatic agents, among others, are not useful for recycling in the food industry.

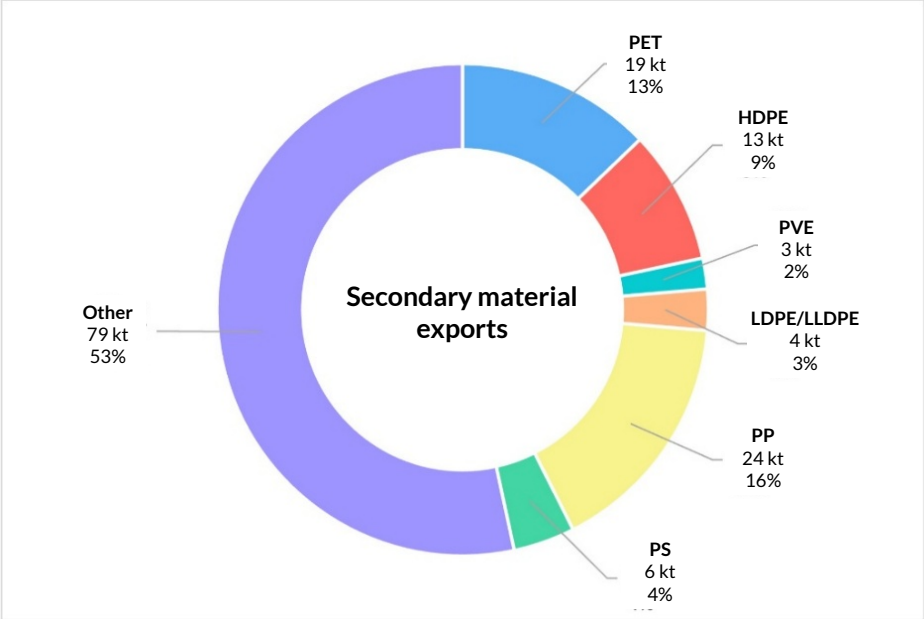
Figure 20. Origin of domestic material recycled, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Trade balance figures reveal Mexico as a net exporter of secondary material (see Figure 21 and Table 24). A total of 148 kt of TP resins were exported, and together they constituted the most significant export of plastic waste. Of these, 19 kt corresponded to PET (13 percent of the total), 13 kt corresponded to HDPE (9 percent of the total), 3 kt corresponded to PVC (2 percent of the total), 4 kt to LDPE-L (3 percent of the total), 24 kt corresponded to PP (16 percent of the total) and 79 kt to other resins (53 percent of the total).

Figure 21. Secondary material exports, 2022



Source: Prepared by the authors with data from UN Comtrade Database and USITC DataWeb.

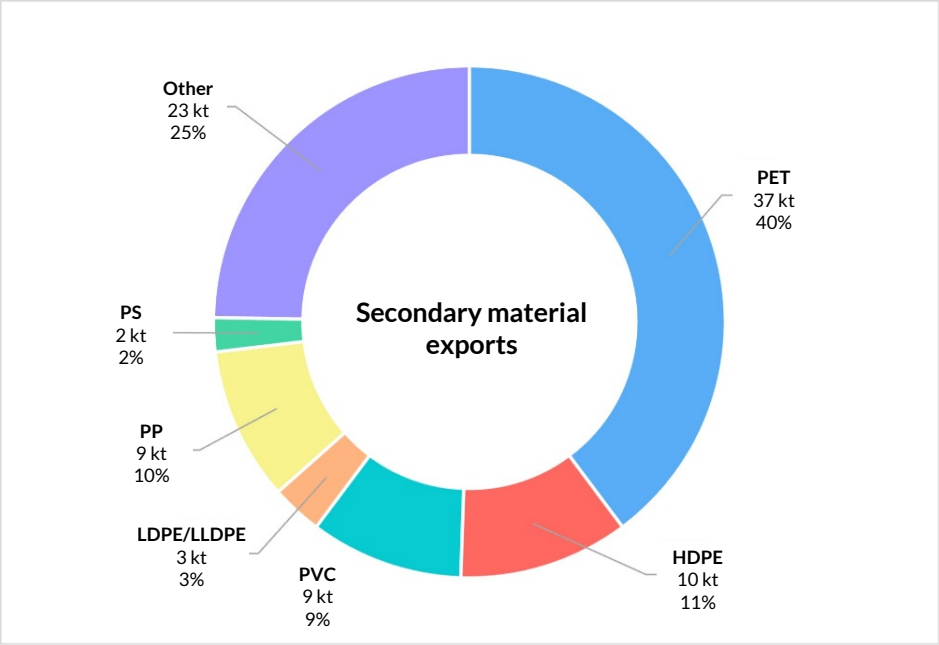
Table 24. Secondary material exports, 2022 (kilotons)

Export of secondary material	Abbreviation	kt	Percentage
1. Polyethylene terephthalate	PET	19	13
2. High Density polyethylene	HDPE	13	9
3. Polyvinyl Chloride	PVC	3	2
4. Low Density/Linear polyethylene	LDPE/LLDPE	4	3
5. Polypropylene	PP	24	16
6. Polystyrene	PS	6	4
7. Other	–	79	53
Total		**148**	**100**

Source: Prepared by the authors with data from UN Comtrade Database and USITC DataWeb.

On the other hand, as shown in Figure 22 and Table 25, 37 kt of PET were imported in 2022 (40 percent of the total), which indicates that PET waste represents the most important waste import. Ten kilotons of HDPE (11 percent of the total), nine kilotons of PVC (10 percent of the total), three of LDPE-L (3 percent of the total), nine of PP (10 percent of the total), two of PS (2 percent of the total) and, finally, 23 kilotons of other TP resins (25 percent of the total) were also imported.

Figure 22. Secondary material imports, 2022



Source: Prepared by the authors with data from UN Comtrade Database and USITC DataWeb.

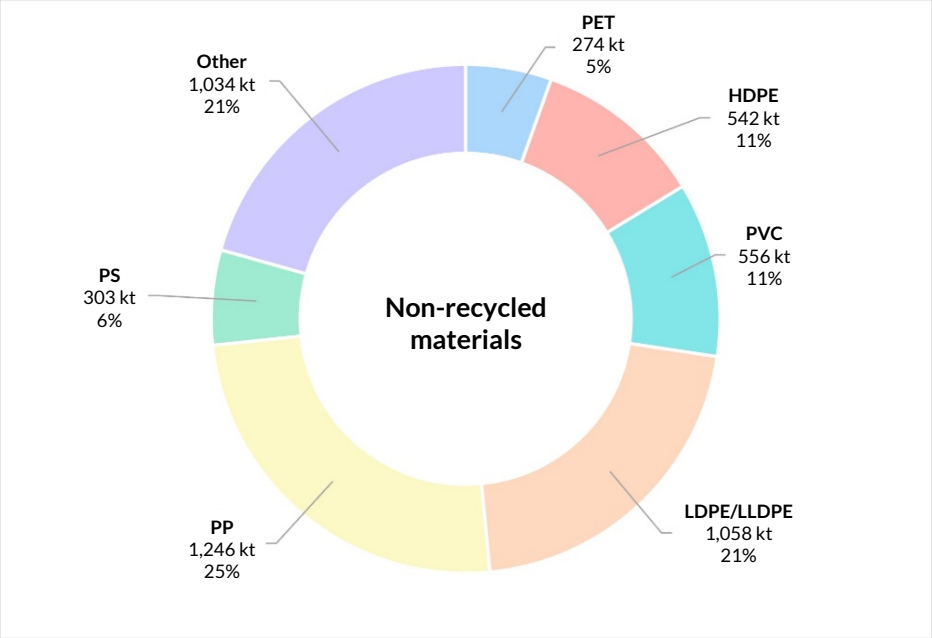
Table 25. Secondary material imports, 2022 (kilotons)

Type of secondary material	Abbreviation	kt	Percentage
1. Polyethylene terephthalate	PET	37	40
2. High Density Polyethylene	HDPE	10	11
3. Polyvinyl chloride	PVC	9	10
4. Low Density/Linear Polyethylene	LDPE/LLDPE	3	3
5. Polypropylene	PP	9	10
6. Polystyrene	PS	2	2
7. Other	–	23	25
Total		**93**	**100**

Source: Prepared by the authors with data from UN Comtrade Database and USITC DataWeb.

In 2022, it was estimated that 5,012 kt of materials were collected and not recycled (75 percent of the total). Of this figure, PP accounts for 1,246 kt (25 percent of the total), LDPE-L for 1,058 kt (21 percent of the total), other resins for 1,034 kt (21 percent of the total), PVC for 556 kt (11 percent of the total), HDPE for 542 kt (11 percent of the total) and PS for 303 kt (6 percent of the total) (see Figure 23 and Table 26).

Figure 23. Materials collected and not recycled in Mexico, 2022



Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

Table 26. Materials collected and not recycled in Mexico, 2022 (kilotons)

Non-recycled materials	Abbreviation	kt	Percentage
1. Polyethylene Terephthalate	PET	274	5
2. High Density Polyethylene	HDPE	542	11
3. Polyvinyl Chloride	PVC	556	11
4. Low Density/Linear Polyethylene	LDPE/LLDPE	1,058	21
5. Polypropylene	PP	1,246	25
6. Polystyrene	PS	303	6
7. Other	Other	1,034	21
Total		**5,012**	**100**

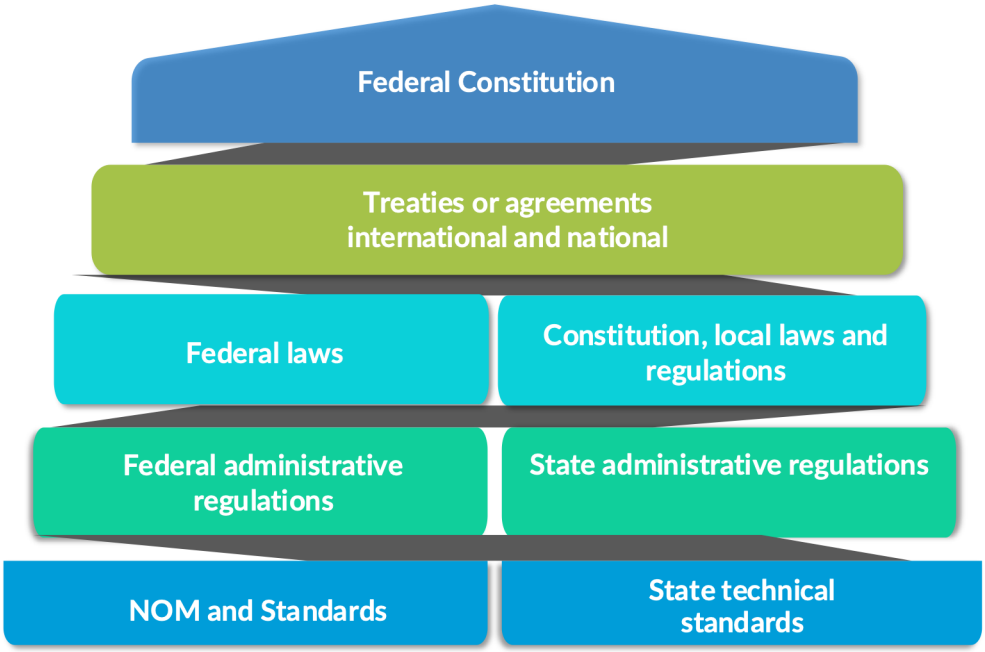
Source: Prepared by the authors with information from the ANIPAC *2023 Statistical Yearbook*.

6. Regulatory Framework

The United Mexican States is a republic made up of 31 free and sovereign states and one, Mexico City, in the process of becoming one. Mexico is made up of 2,500 municipalities, all within a legal framework regulated by the *Political Constitution of the United Mexican States*, international treaties and conventions in which the country participates, general and federal laws, regulations, Mexican

Official Standards (NOM), Standards (formerly known as Mexican Standards or NMX), decrees and agreements, state constitutions and municipal ordinances (see Figure 24).

Figure 24. Hierarchy of the legal framework in Mexico



Source: Prepared by the authors, 2025.

In Mexico there are several environmental laws of national application, such as the General Law for Ecological Balance and Environmental Protection (LGEEPA) and the Prevention and Integral Management of Waste Act (LGPGIR), each with their respective regulations and complemented by Mexican Official Standards (NOM) and Standards. This regulatory framework is also complemented by state laws, regulations and technical standards.

At the municipal level, there are no waste laws, although there are cleanup regulations or bylaws and procedures developed in each municipality. All these regulations make up the Mexican administrative legal framework for waste.

Some instruments are also very important for establishing national public policy on waste, such as:

- The National Diagnosis for the Prevention and Integral Management of Waste
- The National Program for the Prevention and Integral Management of Waste
- The National Program for the Prevention and Integral Management of Special Handling Waste
- The National Contaminated Sites Remediation Program and
- The National Environmental Information System

Semarnat governs environmental policy in Mexico through general acts and their regulations, which must be followed by the state legislatures, which, through their local laws, have the possibility of adapting national legislation to specific problems and conditions. Thus, each state has its own environmental act and regulations.

Semarnat is in charge of carrying out the National Diagnosis of Prevention and Integral Management of Waste, on which the development of the National Program for the Prevention and Integral Management of Municipal Solid Waste and Special Handling Waste is based, which contains, among others, national strategies, goals and actions to improve waste management and optimize its recovery in the country. These documents outline the public policy applicable to all waste generated in the country, while hazardous, mining, metallurgical and petroleum wastes are the exclusive responsibility of Semarnat and Profepa, and special handling wastes are subject to state responsibility through their environmental secretariats or equivalents and local environmental attorneys' offices.

As part of the environmental regulatory framework applicable to municipal solid waste and special handling waste, management plans are one of the most important instruments for achieving coordination between the private sector, government and society, and it is in this instrument that waste streams of local, national and even international interest can develop specific strategies for the care and management of solid waste or plastic, paper or electronic waste, among others.

National waste regulations applicable to plastics are based mainly on the General Law for the Prevention and Integral Management of Waste (LGPGIR) and its regulations, as well as on NOM-161-Semarnat-2011, which establishes the criteria for classifying special handling waste and determining which are subject to a management plan, the list of such waste, the procedure for inclusion or exclusion in such list and the elements and procedures for the formulation of management plans.

Environmental legislation classifies plastic waste from large generators (industry, commerce and services) as special handling waste, and the states are responsible for establishing both its registration and follow-up through management plans that respond to local public policy and the procedures and obligations that the private sector must comply with in their territories.

Large generators, importers, exporters, industry, commerce and services are required to comply with the provisions of NOM-161-Semarnat-2011, or state technical standards applicable at the local level, related to the development, submission and implementation of management plans for post-consumption waste resulting from production activities and direct or indirect marketing of products produced in the state.

These plans include a diagnosis of the waste situation in the country or in the state, as well as the strategies, goals, actions and mechanisms for adhering to other obligated parties, to take advantage of its economic value and, if applicable, increase its recovery, improve its management and optimize

recycling, in addition to establishing the dissemination and communication mechanisms required for the participation of both the population and the government.

6.1 Overview of the federal, state and local regulatory and standards framework

Tables 27, 28 and 29 show the details of the main laws, regulations and standards that are exclusive to plastic waste in Mexico and that affect its management and handling, from the international level to the federal, state and municipal levels.

Table 27. General characteristics of international environmental regulation for post-consumption plastic waste in Mexico

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Basel Convention	1992	Establishes the control of transboundary movements of hazardous wastes and their disposal.	The latest amendment (2020) incorporates principles for the control, regulation, import, transit or export of mixed, halogenated and contaminated plastic wastes.
Agreement that amends the one that establishes the goods whose import and export is subject to regulation by Semarnat	2022	This instrument is associated with the Basel Convention.	30 tariff subsets are established for plastic waste subject to regulation under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, in order to ensure their proper classification, control and traceability at the country's entry and exit points.

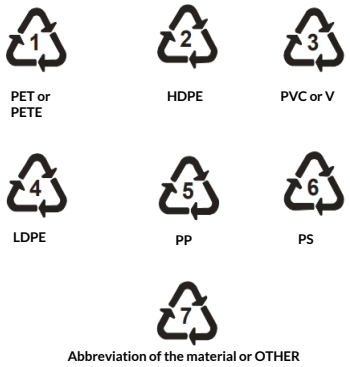
Source: Prepared by the authors based on DOF (2022) and A. Flores *et al*. (2024).

Mexico has adopted measures to strengthen control over transboundary movements of hazardous waste, including plastic waste under the Basel Convention. As a result of the 2020 amendment, which incorporated the regulation of mixed, halogenated and contaminated plastics into the Convention, the Agreement was formulated and published in Mexico in 2022. This instrument allows for proper classification, traceability and control of such waste at the country's entry and exit points, in line with international commitments on plastic waste management.

Table 28. General characteristics of the federal environmental regulation for post-consumption plastic waste in Mexico

Instrument	Year of publication	Scope of application and general description	Impact on plastics
LGPGIR	2003	National. Establishes public policy on waste, which	Establishes the obligation to prepare waste management plans, which

Instrument	Year of publication	Scope of application and general description	Impact on plastics
		includes municipal solid waste, special handling waste, hazardous waste, mining waste and oil waste.	includes plastics in different productive activities and by different generators, such as industry, commerce and services. The amendments and additions to the LGPGIR seek to incorporate bans on single-use plastics and circular economy principles.
Regulations of the LGPGIR	2006	National. It regulates what was established in the LGPGIR.	Establishes the content of the management plan and its characteristics, and applies to plastic waste.
Mexican Official Norms and Standards on waste management			
NOM-161-Semarnat-2011	2011	National. Establishes the criteria for classifying special handling wastes (SHW) and determining which are subject to a management plan and the list of such wastes.	Establishes criteria for classifying SHW and determining which are subject to a management plan; includes plastic waste. This instrument seeks to increase the use or recovery of SHW. At present, there are national and local management plans for the management of post-consumption plastic waste streams such as PET, HDPE, LDPE, PS, PP, PE and their variants. And there are also those for compostable plastic products at the national and state levels, mainly in Mexico City.
NOM-083-Semarnat-2003	2003	National. Environmental protection specifications for the selection, design, construction, operation, monitoring, decommissioning and complementary works of a MSW and special handling waste disposal site.	Establishes environmental protection specifications for the selection and closure of MSW and special handling waste disposal sites.
NMX-AA-015-1985	1985	National. Established the quartering method for municipal solid waste and the obtaining of specimens for laboratory analysis.	Establishes the method to obtain the by-products to be identified in accordance with NMX-AA-022-1985; can be applied for the quantification of plastic waste streams.
NMX-AA-022-1985	1985	National. Establishes the selection and method for the quantification of by-products contained in solid waste.	The list of by-products to be identified includes the plastics stream. These plastic subsets need to be updated according to the new regulations for post-consumption plastic waste.
NMX-AA-061-1985	1985	National. Establishes the selection and method for	Establishes the method for determining, based on statistical

Instrument	Year of publication	Scope of application and general description	Impact on plastics
		determining solid waste generation.	sampling, the generation of solid waste. The list of by-products includes plastics.
Standards in the plastics industry			
NMX-E-232-CNCP-2011	2015	National. Plastics industry: plastic identification symbols.	Establishes and describes the identification symbols that products made of plastic must have. 
NMX-E-267-CNCP-2016	2016	Plastics industry: bio-based plastics - test methods.	Establishes two test methods for determining the bio-based content in resins and plastic products.
NMX-E-273-NYCE-2019	2019	Plastics industry: compostable plastics - specifications and test methods.	Establishes the requirements that plastic products and materials must meet to be considered compostable, and to ensure that biodegradation occurs in a period of no more than six months.
NMX-E-060-NYCE-2020	2020	Plastics industry: plastics terminology.	Establishes the terms related to plastics and unifies the terminology used.

Source: Prepared by the authors based on official sources (DOF) and A. Flores *et al.* (2024).

At the federal level, as mentioned above, the basic instrument for waste regulation applicable to plastic is the LGPGIR and its regulations, as well as the official Mexican standard NOM-161-Semarnat-2011.

By 2025, at least six management plans authorized and in force under this standard for the management and handling of post-consumption plastic waste will be identified in the country:

- Post-consumption waste management plan for PET, HDPE, aluminum and other materials in Mexico, operated by Ecoce since 2012 (Semarnat, PM-ROTR-008-2013).
- Plastic Waste Management Plan for PS, PP, PE and their variants, operated by Rennueva Technologies since 2018 (PM-ROTR-18-2018).

- Polyethylene Film Waste Management Plan, operated by Anguiplast since 2020 (PM-ROTR-019-2019).
- Management Plan for Bags and Plastic Films Marketed in Mexico (PlanBolsa), operated by ANIPAC and Inboplast since 2020 (PM-ROTR-020-2020).
- Management Plan for Plastic and Compostable Products Marketed in Mexico, operated by INIX Comercial since 2021 (PM-ROTR-021-2021).
- Circular Economy and Post-Consumption Packaging Waste Management Plan for the Personal and Home Care Sector, operated by Canipec since 2022 (PM-ROTR-022-2022).

The plastic materials subject to four of these plans (Ecoce, Rennueva, ANIPAC and Inboplast and Canipec), together, report the management of 598,600 tons of plastic waste, which facilitated its use and recovery. Currently, PET is the material with the highest collection percentage, followed by HDPE and LDPE. For the other remaining plans, the associated recovery amount is unknown, as they are individual.

In addition to the above, at the state level, the presentation of "Goods Management Plans" has been established, which refer to goods that when discarded after consumption or use become post-consumption waste, this derived from the new state regulations since 2018 facing concerns regarding the prevention and control of the presence of plastic waste in the sea, beaches and other ecosystems.

On the other hand, the normative instruments of the NOMs on solid waste have an impact on and generally describe the management of plastic waste within solid waste in order to classify, quantify, manage and properly dispose of these materials. The standards also provide standardized methods for identifying, classifying and quantifying solid waste, including some subsets for plastic waste.

In the plastics industry, at least four main standards have been identified which, mainly focused on manufacturers, are of voluntary application. These standards establish the technical criteria for the labeling, identification and homologation of terms for these materials. In addition, at the federal level, there is no standard that establishes the criteria to standardize the terms for post-consumption plastic waste or the content of recycled material in products. However, at the state level, there are states that have already formulated environmental technical standards for these purposes.

To conclude, since 2019, representatives of the Senate, the private sector, international organizations and civil societies in the country have generated initiatives or emerging trends derived from post-consumption plastic bans. These include the National Agreement for the New Plastics Economy, the Mexican Plastics Pact and the proposed General Circular Economy bill, which seek to join multi-sectoral efforts to change the way Mexico approaches plastics management. Overall, these actions have not yet been approved; however, they seek to establish the basis for a multisectoral transition to the circular economy, with co-responsibility between government institutions, industry and civil society. In addition, we seek to articulate these initiatives with global

networks and international standards that progressively strengthen the country's alignment with environmental commitments and legal frameworks.

Table 29. General characteristics of environmental regulation at state and municipal level for post-consumption plastic waste in Mexico

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Aguascalientes Environmental Protection Act	2000	State. Established mechanisms to protect the environment, preserve natural heritage and promote sustainable development of the state.	For sanitary reasons, plastic or PE bags or PS containers may be used when a substitute material cannot be used.
Baja California 1. Environmental Protection Act 2. Prevention, Integral Management and Circular Economy Act	1. 2007 2. 2021	1. State. This law establishes guidelines for the protection of the environment. 2. State. This law establishes the guidelines to regulate the integrated management of waste with a circular economy and life cycle approach in a programmed and gradual manner.	1. In the manufacture of bags, a minimum percentage of 30 percent of recycled material or materials that allow their rapid degradation must be incorporated. 2. Obligation to transition to reusable, recyclable, compostable, usable or recoverable models by 2030.
Baja California Sur 1. Ecological Balance and Environmental Protection Act 2. Ecological Technical Standard NTE- 001-SETUES-2018	1. 1991 2. 2018	1. State. Establishes the regulatory bases for the preservation and restoration of the ecological balance and the protection of the environment, including integrated waste management. 2. Establishes definitive restrictions on the sale and provision of plastic bags, straws and single-use expanded polystyrene containers.	1. Establishes actions for the prohibition and elimination of the use of plastic straws, plastic bags and expanded polystyrene containers for wrapping, transporting, loading or transferring food and beverages. 2. The environmental technical standard regulates these prohibition provisions.
Campeche Integral Management of Municipal, Special Handling and Hazardous Solid Waste Act	2019	State. Establishes guidelines for the prevention, generation, management and integral handling of municipal solid waste, special handling waste and hazardous waste.	Exempt from the restrictions are single-use plastic straws and utensils used in hospitals and for medical needs, or for reasons of hygiene, packaging or food preservation.
Coahuila 1. Ecological Balance and Environmental Protection Act	1. 2005 2. 2020	1. State. Establishes the guidelines for the regulation of ecological balance and environmental protection.	1. Establishes several criteria to be observed to avoid the use of straws, plastic bags and polystyrene.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
2. Prevention and Integral Management of Waste Act		2. State. Establishes the bases for the regulation of the generation, recovery and integral management of municipal solid waste and special handling waste.	Provides for a substitution program and viable alternatives to replace plastic bags and straws with degradable or biodegradable products. 2. The integrated waste program should include incentives and fiscal incentives to replace these plastic products.
Colima Solid Waste Act	2006	State. Establishes the guidelines to regulate the integral management of solid waste considered as non-hazardous, as well as the provision of the public cleaning service.	- Plastic products must comply with the provisions of NMX-E-267-CNCP-2016. - Incorporates research and development (R&D) of technologies to prevent, control and combat plastic pollution. - Incorporates the concept of disposable single-use plastics and provides that the transition to achieve their substitution, elimination and consequent prohibition will be gradual.
Chiapas Environmental Act	2019	State. Establishes the provisions to regulate the protection of the environment in the state.	- Prohibits bags made of HDPE or LDPE, PE, PP, plastic polymer and any other of its derivatives; expanded PS containers (unicel) and polymer-based straws for food use, as well as any product for hygiene or food and fun utensils disposable at first use and made of non-biodegradable material. - Incorporates the concepts of single-use plastics, biodegradable and oxo-degradable materials.
Chihuahua 1. Ecological Balance and Environmental Protection Act 2. Prevention and Integral Management of Waste Act	1. 2014 2. 2018	1. State. Establishes the minimum requirements for the preservation and restoration of the ecological balance and environmental protection. 2. State. Establishes the provisions to regulate the prevention, generation, recovery and integral management of municipal solid waste and special handling waste in the state.	1. It does not contain prohibitions or restrictions on plastics, but establishes as a priority, for purposes of granting tax incentives, the production, promotion, delivery and use of biodegradable plastic bags. 2. It bans plastic straws, but allows those made of reusable or biodegradable materials.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Mexico City 1. Federal District Solid Waste Act 2. Circular Economy Act 3. Technical environmental standard NACDMX-010-AMBT-2019	1. 2003 2. 2023 3. 2019	1. State. Establishes the provisions to regulate the integral management of solid waste considered non-hazardous, as well as the provision of public cleaning services. 2. State. This law establishes powers to encourage and promote the transition to a circular economy. 3. State. Establishes the technical specifications that single-use plastic bags and products must comply with in order to be marketed.	1. Incorporates in its definitions the concepts of biodegradable, biopolymer, compostable, microplastics, plastic, degradable plastics and single-use plastic products. Excluded from the restriction are plastic bags required for hygiene reasons or those that prevent food waste or for medical needs when there are no compostable alternatives. 2. Encourages sustainable production actions through redesign, reduction, reuse, repair, restoration, remanufacturing, repurposing, recycling and recovery, among others. 3. The environmental standard regulates the restrictions and requirements for marketing plastic products in Mexico.
Durango 1. Sustainable Environmental Management Act 2. Prevention and Integral Management of Waste Act	1. 2019 2. 2007	1. State. Issues the criteria for the ecological management of the state. 2. State. Establishes the coordination mechanisms for the prevention of waste generation, recovery and integrated waste management.	1. It contains the chapter "Prevention and control of pollution from the use of plastics", which allows the use, provision or commercialization of ecological bags, reusable or made with recyclable fibers, and cups, cutlery, trays, plates and straws, made with natural polymers. 2. It points out the progressive substitution of products made with PE or any other plastic material, allowing the reuse and recycling of commercial and industrial plastics. Establishes that public agencies and users of such products must seek to implement mechanisms for the reuse or recycling of non-biodegradable plastic products.
Guanajuato Integral Management of Waste Act	2005	State. Establishes the provisions to promote sustainable development through the regulation of the generation, recovery and integrated management of municipal solid waste and special handling waste.	- No plastic bans or restrictions - Seeks to generate actions: 1) to inhibit the use of straws, plastic bags and non-biodegradable products; 2) that waste from these products be subject to a management plan; and 3) that they be phased out gradually.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Guerrero 1. Act No. 593 for the Integral Use and Management of Waste 2. Ecological Balance and Environmental Protection Act 878	1. 2008 2. 2009	1. State. Establishes and integrates waste prevention and integrated waste management policies. 2. State. Regulates, promotes, conducts and evaluates the state policy on management and sustainable use of natural resources and environmental protection.	1. Incorporates the criteria of gradualness and flexibility for the reuse, recycling, treatment and final disposal of containers, packaging, used tires, plastics and other materials. 2. Prohibits plastic carryout bags and expanded PS containers. Commercial and service establishments should replace bags, containers and packaging made of plastic and other non-recyclable materials with others that are reusable, recyclable or biodegradable.
Hidalgo 1. Prevention and Integral Management of Waste Act 2. Environmental Protection Act	1. 2011 2. 2015	1. State. Establishes the guidelines for the regulation of the generation, recovery and integral management of municipal solid waste and special handling waste. 2. State. Establishes the guidelines to regulate and protect natural resources, the preservation and restoration of the ecological balance and the sustainable development of the state.	1. Incorporates the concept of single-use disposable plastics and indicates that the ID of reusable materials and alternatives to single-use disposable plastics should be encouraged. 2. The plastics industry and facilities dedicated to the collection, storage, selection and sale of plastic articles will operate with prior environmental impact authorization.
Jalisco 1. Integral Management of Waste Act 2. Ecological Balance and Environmental Protection Act 3. State environmental technical standard NAE-Semadet-010-2019	1. 2007 2. 2018	State. Establish public policies for waste management in the state and for ecological balance and environmental protection.	1. Support programs for the transition to technologies that use biodegradable, compostable or recycled material from plastic producing companies. 2. Gradual substitution of single-use plastics. 3. This is the state environmental technical standard that regulates the provisions regarding the production of plastic bags and straws.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
State of Mexico Code for Biodiversity	2006	State. Establishes the provisions to regulate five environmental matters in the state, and the third one includes waste prevention and management.	At the beginning of 2025, the restriction of single-use plastics in economic units was unanimously approved, excluding bags or containers that constitute primary packaging, that prevent the waste of goods or that are required for hygiene or health reasons, as well as carryout bags that comply with applicable legal provisions. The use of non-biodegradable or reusable plastics is also prohibited in public offices and in public and private educational institutions. The establishment of actions and measures for gradual substitution is expected. Work is also underway to develop a state technical standard to regulate carryout bags.
Michoacán 1. Prevention and Integral Management of Waste Act 2. Environmental Conservation and Sustainability Act	1. 2010 2. 2021	1. State. Establishes public policies on prevention and integrated waste management in the state. 2. State. Establishes the guidelines to guarantee the protection, conservation and ecological restoration of the environment, environmental education and culture, as well as the promotion of environmental sustainability and the use of clean and renewable energies in the state.	1. There are no provisions for the prohibition of plastics. 2. Establishes the obligation to develop a permanent program based on the circular economy. It seeks to eliminate the use of single-use plastics and expanded PS derivatives, as well as to promote the use of raw materials from renewable natural resources and sustainable recyclables.
Morelos 1. Solid Waste and Circular Economy Act 2. Ecological Balance and Environmental Protection Act	1. 2007 2. 2020	1. State. Establishes public policies on prevention and integrated waste management in the state. 2. State. Establishes the principles of state environmental policy and the instruments for its application in the state.	1. Publication of definitions of plastics and sustainability criteria for the consumption of plastic products; promotion of the ID of technologies to reduce plastic pollution; transition to the use of reusable products; and joint participation of all social sectors.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
			2. Establishes provisions for the gradual transition to the new culture without single-use plastics, as well as the joint participation of the academic, scientific, industrial and civil society communities in the development of a technical-environmental program.
Nayarit Ecological Balance and Environmental Protection Act	2001	State. Establishes public policies on waste management in the state based on the General Law.	- Establishes definitions and actions related to the prohibition of plastic and unicel bags, straws and containers, as well as all raw materials that are toxic or harmful to the environment. - It seeks from the state authority the elaboration of criteria and standards for sustainable production, as well as the principles and general provisions they should contain.
Nuevo León 1. Environmental Act 2. State Environmental Standard NAE-SDS-005-2019	1. 2014 2. 2019	1. State. Establishes public policies on environmental matters. 2. State. Establishes specifications and methods for determining the percentage of recycled material and the use of readily degradable materials in plastic bags.	1. Establishes restrictions to combat, control and abate the pollution generated by the use of plastic straws and single-use plastic bags. 2. The state environmental rule regulates the provisions of plastic bag restrictions.
Oaxaca 1. Ecological Balance and Environmental Protection Act 2. Prevention and Integral Management of Solid Wastes Act	1. 2018 2. 2019	State. Establish the guidelines for the prevention and integral management of waste in the state based on the General Law, as well as for the protection of the environment.	1. The state authority and municipalities will have the authority to prevent the burning of any solid waste, including plastics. 2. The restrictions include straws and single-use bags made of LDPE, HDPE, PP, plastic polymer and any other of their derivatives. There are exceptions to the prohibitions on PET containers for water or other beverages, or when they are intended for medical, educational or humanitarian purposes.
Puebla	2006	State. Establishes the guidelines for the prevention and integral management of waste in the state based on the General Law.	Plastic bags and straws used for hygiene, health or food preservation reasons are exempted from the ban, provided they are made of 100 percent recyclable material.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Prevention and Integral Management of Municipal Solid and Special Handling Waste Act			Prohibits the use of any input whose composition includes oxo-degradable or oxo-biodegradable additives.
	2020	Municipal. Regulation for the prevention and sustainable integral management of municipal solid waste generated (Municipality of San Andres Cholula, Puebla).	It includes provisions for the prohibition of single-use plastics, and incorporates inclusive recycling.
Querétaro Prevention, Integral Management and Circular Economy of Wastes Act	2021	State. The purpose of this law is to regulate the prevention and integrated management of waste in the state, with a circular economy approach.	Seeks to require the integrated waste management program to contain guidelines for the substitution and eradication of disposable plastic carryout bags and single-use plastic straws, cups, plates and other unicel food packaging for wrapping, transportation, loading or transfer purposes, including a dissemination and awareness program among owners of commercial establishments.
	2020	Municipal. Regulation for the prevention, integral management and circular economy of waste of the Municipality of Landa de Matamoros, Querétaro.	Includes provisions for the prohibition of single-use plastics.
Quintana Roo 1. Climate Change Action Act 2. Ecological Balance and Environmental Protection Act 3. Prevention, Integral Management and Circular Economy of Waste Act, which has regulations on extended responsibility derived from this law	1. 2012 2. 2015 3. 2019	1. State. Establishes the framework for the planning and execution of policies in this area. 2. State. Establishes the provisions for the preservation and restoration of the ecological balance, as well as those for the protection of the environment. 3. State. The purpose of this law is to regulate the prevention and integrated management of waste in the state, with a circular economy and life cycle approach.	1. Establishes the collection of plastic containers as a climate change mitigation action. 2. Provides for a plastics substitution program. 3. It is based on the principles of circular economy, life cycle, substitution with returnable products and waste recovery. 4. Recognizes the principles of shared responsibility and extended responsibility of the different sectors. The ban on the use of single-use plastics provides for exceptions for medical reasons, food preservation and safety, equipment handling, construction industry uses, packaging of goods and waste management.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
San Luis Potosí Environmental Act	2009	State. Establishes public policies on waste prevention and management in the state based on the General Law.	It has incorporated several restrictive provisions regarding plastics, as well as the obligation of state and municipal authorities to implement recycling systems and curb the use of plastic bags. Municipalities should promote the installation of plastic waste collection centers. 100 percent biodegradable and compostable food preservation and medical packaging bags are exempted from the restrictions.
Sinaloa 1. Waste Act 2. Environmental Act for Sustainable Development	1. 2018 2. 2020	State. Establish public policies on waste prevention and management, as well as environmental matters in the state.	1. Incorporates definitions of biodegradable, plastic, shared responsibility, extended responsibility, etc. 2. Establishes prohibitions for plastic bags, non-biodegradable plastic products, rings for grouping, holding or carrying containers, expanded PS derivatives and containers without the minimum percentage (90 percent) of recycled plastic content. The plastics industry requires prior environmental impact assessment.
Sonora 1. Ecological Balance and Environmental Protection Act 2. Act regulating the production, handling and final disposal of municipal solid waste, special handling waste and single-use plastic products	1. 2008 2. 2021	State. Establishes public policies on waste prevention and management and environmental protection in the state.	1. Plastic bags must contain at least 10 percent recycled plastic in their composition. The state program for the minimization, reuse and recycling of plastic waste is introduced. 2. It provides for a single-use plastics management program; a registry of manufacturers and distributors of single-use plastics; collection, handling and disposal schemes for biodegradable plastics; a levy scheme for suppliers of single-use plastic products; and incentives to achieve a circular economy and for innovation.
Tabasco 1. Prevention and Integral Management of Waste Act	1. 2012 2. 2019	State. Establish public policies on waste prevention and management, as well as environmental protection in the state.	1. Establishes for the plastics industry certification systems for processes or products to induce consumption patterns that are compatible or that preserve, improve or restore the environment.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
2. Environmental Protection Act			2. Includes hospital plastic waste in special management plans, and incorporates the term "agroplastics". Foresees that all social sectors, including women and Indigenous populations, will be taken into account in the definition of sustainable consumption actions.
Tamaulipas Sustainable Development Code	2008	State. Established the basis for regulating and promoting compliance with environmental protection and comprehensive management of waste.	- Provides for research and development (R&D), as well as the application of technologies, equipment, processes and systems to prevent, control and reduce pollution in the production, use and disposal of plastic bags. - Plastic bags that include a minimum percentage of 30 percent recycled material and that are of swift degradation in accordance with NMX-E- 267-CNCP-2016 are exempt from the ban.
Tlaxcala Ecology and Environmental Protection Act Waste Act of the State of Tlaxcala	n.d.	State. Establishes public policies on ecology and environmental protection.	It does not provide for prohibitions or restrictions.
Veracruz Prevention and Integral Management of Municipal Solid and Special Handling Waste Act	2004	State. Establishes public policies on waste prevention and management in the state based on the General Law.	- Seeks the gradual transition to the use of biodegradable materials. - Gradual prohibition of the use of plastic bags and straws in commercial establishments. - Recognition of the principles of sustainable production and consumption, as well as reduction, recycling and reuse.
Yucatán Integral Management of Waste Act	2011	State. Establishes public policies on waste prevention and management in the state based on the General Law.	- Seeks the gradual reduction of single-use plastic carryout bags, polystyrene containers and plastic straws in commercial establishments. - Provides for a management plan for the respective waste management and public awareness campaigns. - Promotes the use of raw materials from renewable and recyclable natural resources.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
			- Exemption of single-use plastic carryout bags with a minimum percentage (30 percent) of recycled material, as well as biodegradable bags and straws.
Zacatecas Control of Contamination Derived from the Use of Disposable Products Act	2021	State. Establishes public policies on the prevention and management of contamination of disposable products in the state.	- It is based on the global responsibility of governments to combat and eradicate the pollution generated by the indiscriminate and irrational use of plastic and disposable products. - Straws can be used for medical reasons, biodegradable containers when the use of tableware is impossible, and reusable containers.

Source: Prepared by the authors based on various official sources: DOF, official state newspapers and A. Flores *et al*. (2024).

Table 29: in the area of plastic waste, the position of state authorities is varied, although three can be clearly identified: the imposition of taxes, total or partial prohibition accompanied by mandatory substitution with environmentally friendly plastics, and a mixed position that includes the promotion of recycling rates and the search for circular rather than linear economies.

The modifications or new regulations established at the state level are summarized in the following data:

- From 2016 to 2018, 245 bills were before legislative congresses that would ban, replace or reduce the consumption of single-use plastics. A total of 26 states had approved laws or some type of provision for environmental protection or solid waste prevention and management.
- Between 2018 and 2019, four states (Baja California Sur, Mexico City, Jalisco and Nuevo León) formulated environmental or ecological standards for the regulation of bans on post-consumption plastics, establishing guidelines for the possible marketing of products required for hygienic reasons. Criteria were also established for obtaining registrations, labels or certifications at the local level.
- By the end of 2021, only Quintana Roo and Baja California have state waste management regulations with a circular economy perspective. At the local level, two municipalities (Landa de Matamoros, Querétaro, and San Andrés Cholula, Puebla) have regulations prohibiting the use of plastics.
- By 2025, thirty of the 32 states have approved restrictions on the use of single-use plastics. The two that have not approved the ban are Guanajuato and Tlaxcala.

- Of 32 states, twelve (Aguascalientes, Baja California, Coahuila, Colima, Chihuahua, Durango, Guerrero, Hidalgo, Morelos, San Luis Potosí, Tamaulipas and Yucatán) have focused their provisions on promoting the production and preferential research and development of products made from compostable, biodegradable or natural fiber materials, which has a direct impact on the availability and demand of the international market. Likewise, there are authorized state management plans for compostable and reusable products for hygienic reasons, although plastic products for medical use are excluded.

Table 30. International and national certifications that have an impact on plastic waste management and recycling in Mexico

Instrument	Year of publication	Scope of application and general description	Impact on plastics
International			
1. ISO 14020 - General terms and requirements 2. ISO 14021 -Self-declaration 3. 14024 - Eco-labeling 4. 14025 - Environmental declarations for products	1. 2022 2. 2016 3. 2018 4. 2006	International voluntary	Applies to labels of various products focused on environmental criteria.
Global Recycled Standard (GRS)	2008	International voluntary	The certification of textile products has been extended to plastic products to demonstrate their recycled plastic content.
Carbon Trust Standard-Zero Waste to Landfill	2012	International voluntary	Recognizes efforts to reduce carbon emissions and the environmental impact of production processes, with application to the plastics industry.
Recycled content certification	1989	International voluntary	Independently verifies the percentage of recycled content in a product or material.

Instrument	Year of publication	Scope of application and general description	Impact on plastics
Guidelines of the Association of Plastic Recyclers [APR, United States]	Various dates	International	Design for Recyclability Guidelines are available to guide designers, specifiers and purchasers of plastic packaging in the United States and Mexico. These guidelines cover eight base plastic materials, including PLA or polylactic acid, and all packaging elements, such as pigments, labels, caps, etc. In addition, there are guidelines for rigid containers other than bottles, as well as for thermoformed packaging.
National			
Clean Industry Certificate	1992	National. Government of Mexico through the Ministry of the Environment and Natural Resources (Semarnat-Profepa)	The environmental certificate recognizes the environmental performance of an industry according to its activity. Companies engaged in manufacturing and processing activities (e.g., chemical, paper, petrochemical, plastics, oil refining, among others).
ANIPAC Label Operation Clean Sweep Blue [OCS Blue]	2019	National voluntary industrial	This is a new level of recognition for companies committed to the application of the Zero Pellet Loss Program tools, having worked for two consecutive years in the program.
Circularity Label	New: 2025	State: Mexico City	It is granted to companies that comply with the Circularity Criteria established and reaches different levels, depending on the degree of compliance.

Source: Prepared by the authors based on Sinox Polymers, SCS Standars (2024), S. Garcia (n.d.), ISO 14024 (2018), APR (2025), Sedema (2025) and ANIPAC (2025).

Internationally, there are several specific standards and certifications for plastic products. Their application is usually voluntary and focused on the private sector, which can incorporate

environmental criteria in the design, labeling and marketing of plastic products. These tools strengthen environmental communication between producers, consumers and authorities by providing reliable mechanisms for declaring attributes such as recyclability, recycled content or environmental performance of processes.

As mentioned, these standards are voluntary. It should be noted that they are widely used as a technical reference, although their formal adoption depends on the interest of each company in becoming certified.

In Mexico, it is mainly brand owners who seek to become certified or use these international criteria to provide transparency and competition in national and international markets. The APR (Association of Plastics Recyclers) Guidelines are used by designers, manufacturers and recyclers of PET containers to improve the recyclability of their products. However, there is no consolidated public registry indicating the exact number of Mexican companies certified in each standard.

In the case of voluntary national certifications, three main ones were identified: the Clean Industry Certificate promoted by Semarnat-Profepa, the Operation Clean Sweep Blue Label (OCS Blue-ANIPAC) and the Mexico City Circularity Label. Together, these public and private awards reinforce compliance and transparency, and boost the responsible competitiveness of industries by promoting good practices, particularly in the plastics industry and related sectors.

It can be concluded that Mexico still has gaps in formal certification, particularly for recycled content in single-use post-consumption plastic products, and especially in comparison with international standards.

The fact of not having these standards makes it difficult to differentiate and provide transparency in the composition of plastic products, since due to the prohibitions some states in the country have issued their own environmental technical regulation standards, which establish different minimum content indexes or their substitution with natural or compostable materials.

Shared and differentiated responsibility

In Mexico, the General Law for the Prevention and Integral Management of Waste considers shared responsibility as the way in which the governmental and private sectors can interact with respect to municipal solid waste and special handling waste, for which management plans appear as the main instrument.

At the international level, since the 1990s, extended producer responsibility (EPR) has been a form of public policy that seeks to hold producers financially and physically responsible for the environmental impacts of their products throughout their life cycle, and uses as a fundamental basis the “polluter pays” concept and the internalization of the costs of recycling or disposal of the product at the end of its useful life, which the final generator does not usually want to assume. In theoretical terms, this situation leads to a model of manufactured products that are more durable, recyclable and use fewer natural resources and have a lower environmental impact.

Different EPR schemes have been adopted around the world, and this CEC study shows the ERP schemes followed by Canada and the United States. In Mexico, the scheme to be followed is based on shared responsibility throughout the country, a condition established in the LGPGIR, which establishes the Waste Management Plan as the main instrument of Mexican environmental policy that promotes the joint, differentiated and coordinated participation of the different actors in the value chain, in order to improve the management, handling and recovery of waste.

At the national level, the waste streams that have companies or associations that address these issues are listed below:

- various plans for different types of plastics, films, packaging, bags and others
- miscellaneous plans for waste electrical and electronic equipment
- discarded used tires
- paper and cardboard
- construction and demolition waste

Likewise, some Mexican states, including Mexico City, Estado de México, Querétaro, Jalisco and Nuevo León, have procedures and formalities related to the submission of management plans to address some waste streams of local concern, where plastic and electronic waste are again the main concerns and the registration established in the LGPGIR for management plans is an activity that neither the private sector nor the public sector applies. States such as Estado de México, Jalisco, Tamaulipas and Sinaloa have expressed the possibility of recognizing the management plan, but state registration in a national management plan is rare and requires analysis and homologation work.

The structure and content of a management plan is subject to the provisions of NOM-161-Semarnat-2011, with a shared responsibility scheme that, in accordance with the provisions of the LGPGIR, allows the private sector to assume responsibilities associated with the recovery of waste and its materials and recycling for the manufacture of new products, similar to the results expected from the application of extended responsibility schemes.

7. Identification of Best Practices Applicable within Mexico

This section shows the best practices that can be applied to promote circularity in the plastic that is produced, imported, marketed, generated and recycled within Mexico, and that supports the industry's operations, processes and mechanisms to increase the reuse, recovery and recycling rates of products and materials in the country.

Identifying these practices was based on the analysis of the activities and personnel who contribute to the value chain of this material in Mexico, researched on available documents and publications, and considering as the main source CEPI's Good Manufacturing Practices Guide, 2010. The Guide is considered complete because it provides clear elements of good practices, not based on

examples, but rather on implicit, structured recommendations that strengthen its usefulness as a technical and regulatory reference for the sector. It also includes some findings from working group meetings with personnel in the plastics value chain.

All these practices focus on improving operations, increasing control and reducing losses, and considering human, material and economic resources in the different stages of the value chain.

For this section, applicable best practices were grouped according to the stages of the plastics value chain (see Figure 2), and comprising the following items:

- Best practices in raw materials and manufacturing
- Best environmental practices at the raw material and manufacturing stage
- Best practices for marketing and distribution activities
- Best practices for consumption activities
- Best practices for recycling and circular economy activities

The raw material and manufacturing stage considers quality assurance practices, health and hygiene and risks; it takes into account the reduction in waste generation by integrating operations, the proper handling of raw materials by industry workers, the procedures and technology used to reduce losses or take advantage of the materials used in productive activities of any kind, and once the waste is generated, its proper handling for greater use and better final disposal.

The good practices applicable to the raw material and plastic manufacturing stages are shown in Table 31.

Table 31. Best practices in raw materials and manufacturing

Activity	Description	Result
Quality assurance system	The sum of organized and documented provisions adopted to ensure that materials and objects have the quality required to comply with the applicable norms and consumer quality standards necessary for the production activity.	The requirements for plastics that will have food contact applications are governed by the requirements of the end application and are intended to ensure safety and quality suitable for the intended use. This implies that the plastic must be manufactured according to one or more agreed-upon quality standards.
Quality control system	Systematic application of the measures established in the quality assurance system for starting materials and intermediate and finished materials and objects.	Currently, the plastics industry already has the technical standards to ensure the quality of the secondary raw material recovered, especially in terms of the physical characteristics of the products.

Activity	Description	Result
Documentation	Proper documentation is important; however, it is not necessary to develop and continually maintain a complete file of all information. Plastics manufacturers, though, should be able to make any relevant information available to the competent authorities upon request and within a reasonable period. Two years is recommended a minimum custody period.	Folders with the indicated information.
Labeling	Labeling assists users in the correct use of materials and objects, even though the methods used for such labeling may vary from user to user. The information content is not the only aspect to consider; the material of which it is made, and the inks and adhesives are also elements to be considered for the use of labels that directly impacts the recyclability of a product.	Folders with information on changes in labeling, change of materials, especially for lids and labels of the same material as the container.
Traceability	For the manufacturing industry, this consists of having clear records of information from the supply chain, distribution and retailing to the final consumer. To facilitate the recall of defective products, traceability from the recycled plastic plant to the container or packaging or article must be ensured. Traceability in the recycling industry involves maintaining information from the collector and origin of post-consumption or post-industrial waste and collection centers to the manufacturing or recycling plant.	ANIPAC is working on the development of a technical standard that defines the characteristics and procedures to demonstrate the traceability of post-consumption waste.

Source: Prepared by the authors based on the CEPI Guide to Good Manufacturing Practices (2010).

Quality assurance ensures that materials and objects are produced, implemented and controlled in a consistent manner, pursuant to the applicable norms and quality standards of the intended use, so as not to endanger human health or cause, through poor operating practices, or a change in pellet waste generation.

Although the size of the industry and the nature of its production activity impact the development of the business, it is also true that adaptation can work the other way: that financial and personnel conditions and the technologies used must also be considered for the application of these good practices. These good practices apply to formal productive activities, and not to informal activities such as those carried out by garbage pickers or similar.

From an environmental perspective, best practices applied to the manufacturing stage are described below (see Table 32):

Table 32. Best environmental practices at the raw material and manufacturing stage

Activity	Description
Use of raw materials	Reducing losses of pellets in handling the raw material is in the interest of companies, such as Braskem, which applies technical training programs for this purpose. Likewise, changes that replace fossil fuels with biodegradable and compostable raw materials are desirable; however, changes to using former agricultural areas for industrial uses rather than food purposes are questionable, since a multifactorial analysis is required to determine the convenience of using an agricultural area for energy generation or plastics production.
Recycling	Implementing an effective recycling system to recover used plastic not only reduces the need for new raw materials but also reduces the amount of waste.
Energy efficiency	Use technologies and machinery that consume less energy. The implementation of renewable energy sources, such as solar or wind, can also be beneficial.
Water reduction	Minimize the use of water in the manufacturing process. This can be achieved by reusing process water and implementing technologies that reduce consumption.
Emissions controls	Install filtration and gas treatment systems to reduce pollutant emissions during production. This helps compliance with environmental regulations and protecting public health.
Product innovation	Develop biodegradable, compostable, or reusable and recyclable plastic products in order to contribute to a more sustainable life cycle. It is important to consider all the advantages of eco-design.
Personnel training	Invest in employee training for sustainable and efficient production practices. A well-informed team can make a significant contribution to continuous improvement
Monitoring and continuous improvement	Implement a monitoring system to evaluate the environmental impact and efficiency of the production process. This will allow areas for improvement to be identified and practices to be adjusted, as necessary.

Source: Prepared by the authors based on the CEPI Guide to Good Manufacturing Practices (2010).

Best practices for plastic marketing and distribution activities are presented in Table 33.

Table 33. Best practices for marketing and distribution activities

Activity	Description
Route optimization	Plan efficient distribution routes to minimize fuel consumption and reduce carbon emissions. Using logistics software can help find the shortest and fastest routes.
Use of sustainable packaging	Opt for recycled or reusable cardboard packaging. This not only reduces environmental impact but can also be an attractive selling point for consumers.
Load consolidation	Group shipments to maximize the use of space in transport vehicles. This reduces the number of trips and, therefore, the consumption of resources.
Eco-friendly transport	Whenever possible, use more sustainable means of transportation, such as electric or fuel-efficient vehicles for the distribution of plastic products.
Distributor training	On sustainable practices and the importance of handling plastic responsibly during transportation.

Source: Prepared by the authors based on the CEPI Guide to Good Manufacturing Practices (2010).

Best practices for plastic consumption activities are presented in Table 34.

Table 34. Best practices for consumption activities

Activity	Description
Responsible use	Encourage the conscious use of plastic products, such as promoting ink-free engraving and the use of recycled plastic and mono-materials. This helps reduce the demand for new raw materials.
Recycling	Establish recycling systems in offices and homes to recover post-consumption plastic for recycling. Provide specific containers to facilitate this process.
Digitization	Promote the digitizing of documents and processes to reduce dependence on plastic. Use digital tools for communication and information storage.
Consumer education	Inform consumers about the importance of choosing recyclable and recoverable plastic products. This can influence their purchasing decisions.
Reuse	Encourage the use of reusable plastics instead of simply discarding them. For example, use plastic boxes for storage or crafts.
Preference for sustainable products	Encourage the choice of brands and products that are committed to sustainable practices in the production, distribution and recycling of plastic.

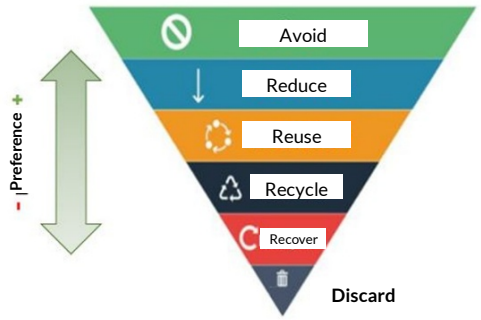
Source: Prepared by the authors based on the CEPI Guide to Good Manufacturing Practices (2010).

Increasing the recycling of plastic waste extracted from solid waste, considering the value chain that exists in Mexico with local regulations and current markets, implies not only increasing recycling rates, but also promoting sustainable and eco-friendly methods that benefit both the environment and the industry. The implementation of these best practices requires close collaboration between all participants in the value chain, from garbage pickers to plastic product manufacturers and, above all, to the end user. All must reduce their requirements for product overprotection, to ensure an holistic and efficient approach.

In the best practices shown in Tables 32 and 35, the convenience of using secondary raw material is established, where Mexico has achieved high percentages of PET bottle recycling, and it is recognized that the recovery of post-consumption waste is an important activity to strengthen not only in PET but also in PP, PE, PS to protect the environment and reduce pollution without forgetting that due to their economic value, recyclability and reusability, they represent areas of opportunity. Although the percentage of PET recovery and recycling in the country is low, there are always good practices that those involved in the value chain can design and apply.

Table 35. Best practices for recycling and circular economy activities

Activity	Description
Diagnostic	A detailed diagnosis of waste generation and the integrated public and private infrastructure will allow identification of complementary recovery areas that increase recovery, as well as the types and quantities of plastics that can be recovered. An example is thermoforming, where the amount of material recovered is low although there are large areas of opportunity, as well as waste from localities and areas with lower recovery coverage.
Implementation of containerization schemes.	Containerization for source-separated waste recovery is an activity that directly impacts the amount of waste recovered. It is recognized that it would favor informal activity, but in Mexico, schemes have been observed that demonstrate the benefit of its use. The facility should be erected in visible locations, as a complementary scheme to the cleaning service, and requires a location study and development of recovery logistics. This activity includes the acquisition of vehicles with additional equipment.
Training	This activity is very broad and should include the participation of several actors in the value chain, and training should be differentiated and in accordance with the characteristics of specific activities.
Design and application of rates	This activity is desirable because it makes it possible to allocate the economic resources required for the construction, operation and maintenance of the cleaning system, from dissemination and training to collection, transportation, recycling and final disposal. Compliance with the “polluter pays” principle is based on the design and implementation of differentiated fees that recognize the requirements, efforts and social condition of the actors.

Activity	Description
Design and development of operating agencies	Public policy for waste management requires medium- and long-term plans that allow for human, financial and infrastructure resources to guarantee adequate waste management. These operating agencies could be constituted as a public service established in the LGPGIR, so they must have financial independence, their own resources and mixed control schemes. With these services, it is recognized that operation requires technical expertise and long-term business models.
Performance indicators and assessments	To evaluate the effectiveness of waste management, it is important to establish performance indicators to measure compliance with established objectives and goals. Relevant indicators could include the amount of post-consumption or post-industrial plastic recycled, the reduction of non-recyclable waste and the level of societal participation. The evaluation should also include aspects such as periodic performance audits to assess the efficiency of services based on accurate and timely information, as well as follow-up and feedback to identify areas for improvement.
Inventory and information generation	Retrieve and analyze data related to infrastructure, quantity and types of waste generated, waste disposed of in sanitary landfills and recovered for recycling, as well as local programs and projects. Inventories with standardized information allow for the development of infrastructure and public policy programs and projects, as well as national, state and municipal programs with specific regulatory and problem-solving actions.
Application of the inverted triangle of integrated waste management	Recognize the hierarchy in Integrated Waste Management (IWM) and apply strategies in actions according with this hierarchy and its application in the management of the waste generated, not only for plastic waste but for all waste generated by human activities, providing structured elements for the development of public policy in waste management. 
Use of the best available technologies	The operational structure of garbage pickers and the different scale of operations of the collection centers require the best available technology for collection, weighing, transport and delivery. The collection centers require compacting and, in some cases, sorting equipment to improve the quality of the bales to be sent to manufacturing or recycling plants for plastic waste. The use of optical sorters, ballistic separators and automated equipment is desirable, but since the socio-economic conditions of the grassroots actors are limited, it is advisable to focus technical modernization on recovery and recycling in economies of scale and to include black products in these strategies.

Activity	Description
Strengthening regulations	Improving provisions subject to the circular economy requires national strategies of sufficient strength that the same actions and goals will be carried out throughout the country. Plastic recycling, which is homogeneous in the country due to the enacting of similar legislation and procedures, combines the efforts of the main plastic manufacturers and recyclers in Mexico. The regulatory framework obligates generators to uphold the objective of broadening the recovery base to some plastics with recovery opportunities, such as: • Thermoforming • Mixed plastics • Foamed plastics • Fast food and packaging material Plus: Application of fees and penalties for non-compliance with the law.

Source: Prepared by the authors, 2025.

8. Findings and Recommendations

As this study developed, the various activities associated with the management of post-consumption plastic waste yielded certain findings that were then identified and organized principally by theme.

The findings thus identified did not seek to issue opinions about the facts that had been discovered but rather described those that really contributed information or knowledge about the handling and management of plastic waste in the country.

This section describes the findings, numbered and ordered by topic, together with corresponding recommendations for improved service.

8.1 General aspects of handling and management of plastic and solid urban wastes

Finding 1

Cleaning systems are unevenly managed and distributed across the country, largely because they offer free services and have a low budget for waste collection: $434.03 per ton collected and $121.58 per ton for final disposal. The budget allocated does not allow waste management to have sufficient material resources and infrastructure to allow good services and achieve complete coverage throughout the country.

Recommendation 1. Implement fees, differentiated according to application and destination by activity, allowing sufficient resources for complete coverage according to the service, and for management to be paid sufficiently such that the equipment and infrastructure can be kept up to date, as necessary for managed recovery of waste.

Recommendation 2. Establish government centers for collection of waste located closer to the population, to have better separation of waste disposal, including the sale of waste to the recycling or manufacturing sector. This process will enable the government to have additional financial resources for waste management.

Recommendation 3. The budget necessary for a good sanitation system would take into account differentiated collection fees, with revenues from the sale of materials recovered at sorting plants and collection centers and, in advanced stages, the generation of energy from waste with thermal value, all operated by the government or in public-private schemes.

Recommendation 4. For municipalities with no cleaning services and with an Indigenous population, direct intervention is needed to implement solid waste collection, mainly for inorganic waste, as well as joint coordination with the private sector to provide these municipalities with at least the minimum infrastructure for the management of waste with recovery potential.

Recommendation 5. Enforcement of sanctions to reduce improper waste disposal, as indicated in the corresponding laws.

Finding 2

Having numerous disposal sites is considered good waste management; however, this is valid only for sanitary landfills that comply with the standards indicated in the applicable legislation. Many municipalities have only uncontrolled sites. Even those with controlled sites usually find that this does not prevent the release of plastic wastes, greenhouse gases or leachates into the environment, thus violating the guarantee of care and access to a healthy environment established in the Constitution.

In addition, some states were identified whose final disposal is carried out in sanitary landfills located in other states. Although these sites comply with applicable environmental regulations, they operate under specific regional criteria, which poses challenges in terms of traceability, regulatory harmonization and interjurisdictional control.

Recommendation 1. The lack of economic resources or technical capacity has a direct influence on the situation described above. In addition to the suggested fee implementation mentioned in recommendation 1 of Finding 1, above, the disposal of waste in another municipality with verifiable sanitary landfills should be evaluated. This is the practice in Mexico City, which does not have any final disposal or special handling site for municipal solid waste. Federal or local governmental guardianship is clearly vital in carrying out this strategy.

Recommendation 2. In the absence of space or a final disposal site, it is necessary to resort to strategies such as prohibiting the reception of other waste, as is the case with waste of obvious economic value, such as metals, PET, PP, PE and PS plastics, construction waste or electrical and electronic waste. The correct application of this strategy involves the private sector and state promotion strategies.

Finding 3

There are municipalities with a high potential for plastic waste recovery due to their populations of more than 500,000 inhabitants and their few collection centers, such as Mexicali, Baja California; Reynosa and Matamoros, Tamaulipas; Benito Juárez, Quintana Roo; Centro, Tabasco; Culiacán, Sinaloa; and Saltillo, Coahuila.

Recommendation 1. Call on the private sector to set up collection centers or promote them and buy the recovered material from them. Also, the government should assume the role of guarantor so that the activity can be sustained over the long term.

Recommendation 2. An alternative would be the installation of collection centers by the government, without the participation of any other body, and then all the profits from the sale of waste go to the state. A possible alternative would be to enter into an agreement with an operator but, in that case, the application must be properly evaluated to avoid repeating the traditional patterns of lack of follow-up and erratic management.

Recommendation 3. A further recommendation would be to have an updated list of individuals and companies which provide private collection services and waste collection centers. Close coordination between state and municipality could provide governance in this scheme and complement it with information services for the population, detailing the sites and the services they offer.

Finding 4

In Mexico there are at least 150 municipalities without waste collection services, 86 of these are in the states of Oaxaca, Puebla and Veracruz, and have a high Indigenous population and lack the infrastructure to solve their waste management problems, especially that of inorganic waste.

> **Recommendation 1.** The application of strategies based on some form of containerization is valuable if it is complemented by periodic collection, only for the inorganic waste, for shipment of that to sanitary landfills in other municipalities.
>
> **Recommendation 2.** Resolve access to remote locations or municipalities, as connectivity is key to solving problems related to waste handling, management and utilization, among others.

Finding 5

Post-consumption waste recovery was identified as low, despite significant opportunities to increase recycling rates and materials for the manufacture of new products.

> **Recommendation 1.** The viability of constructing a new sorting plant must consider the impact of garbage pickers in the value chain, since the risk of receiving waste without a high content of material for recycling would make the scheme unviable. The by-products of the plant must be sufficient to guarantee its financial operation, which also includes the production of refuse-derived fuel (RDF), where the greatest benefit is obtained from the generation of energy.
>
> **Recommendation 2.** Establishing adequate waste management as is obligatory for all private collection companies, so as to remove something of material or energy value associated with plastics and reduce the amount of waste sent to sanitary landfills as its final destination.
>
> **Recommendation 3.** E-commerce and its delivery are activities that should be regulated in the same way as the activities required by management plans, including extended responsibility schemes.

8.2 Actors and post-consumption waste recovery

Finding 6

Garbage pickers, who today play an important role in the recovery of plastic waste, are informal actors who extract the waste from the mixed garbage and sell it at the collection centers without tax invoicing to prove the monetary transaction, a situation that impacts the first buyers in the value chain related to the management, handling and recovery of waste due to the lack of a formal mechanism to prove the acquisition and legal origin of the raw material.

> **Recommendation 1.** Address the tax issue from the first purchase, allowing the first buyers to recover any amount of waste possible, always through balances before the corresponding authority.

Finding 7

The collection centers are key in the recovery of cleaner waste in their operations, waste whose source is the garbage pickers, the population and the large companies that generate plastics. However, they influence the costs of the material that reaches the recycling or remanufacturing industry, as they sometimes increase the value by up to 100 percent for each level of actor involved.

> **Recommendation 1.** Establish a communication mechanism—without intervention, only informative—that shows the price of the material on the market, the price of the raw material and the price of post-consumption waste.
>
> **Recommendation 2.** The installation of containers on public roads facilitates the collection of waste from garbage pickers, but they could also be used by collection centers or by industry. Selecting the mechanism could be a matter for tenders or could be the responsibility of the municipal government and offer the recovered waste at a commercial price.

8.3 Market

Finding 8

The most recycled plastics in Mexico are PET, high- and low-density polyethylene, polypropylene and PS, where stretch wrap is in high demand. Post-consumption plastic waste from the food sector is a focus of interest for recycling and appears to be the main source of plastic contaminants. All plastics present areas of opportunity for increased recovery of post-consumption waste, but there are also always technical complications in their recovery and recycling.

> **Recommendation 1.** Encourage the use of APR guides, which provide information on the best conditions for plastics in terms of labeling, type of material, color and content, and help the government and society in general to identify the plastics that recycle best.
>
> **Recommendation 2.** Jointly design government and private sector schemes for the correct management of plastics with no economic interest, including rigid and flexible plastics, with or without chemical compounds such as persistent organic pollutants, heavy metals, antistatic or other substances. Adequate facilities should be promoted to eliminate the practice of burning, disassembling or recovering materials on public roads or in uncontrolled disposal sites.

Finding 9

The value chain supported by garbage pickers requires fiscal arrangements that recognize this step and at the same time allow the first buyer to acquire as much as possible, in addition to providing them with social security and adequate working conditions.

> **Recommendation 1.** Focus on social support schemes for garbage pickers who work in controlled and uncontrolled final disposal sites, so that they have basic equipment, such as gloves and masks, to work in better conditions.

Recommendation 2. The government should have a census of all garbage pickers that serves as a reference for the first purchase of post-consumption waste by collection centers or collectors with regulated business activity.

Recommendation 3. The first purchaser should have fiscal assurance that the direct purchase from the garbage pickers is recognized in the actual quantities purchased and in accordance with the balance sheets presented.

Recommendation 4. Develop and make available to the public the market prices of post-consumption waste by type of material, origin and condition, so that anyone can know the actual price per day for commercial transactions. This reduces discretion and price manipulation by monopolists.

Recommendation 5. Over the medium term, integrate garbage pickers into a sorting plant that allows for recovery on a larger scale, in order to reduce economic impact on the plants already built and operating, and as a result of handling waste with little value for recycling.

Finding 10

Best practices are considered to provide specific good elements whose knowledge should be promoted and their application expanded in all sectors, including consumers.

Recommendation 1. Promote with business leaders the application of best practices at any level of the value chain and its actors, whenever they carry out industrial, commercial or service activities.

Recommendation 2. That the government assume the dissemination of best practices among consumers through the institutions destined for this purpose, such as Profeco, Conocer, various universities, training centers and nongovernmental organizations.

Finding 11

Dirty or highly contaminated plastic waste are not permissible for recycling or they make it so expensive that it is not viable for the recycler.

Recommendation 1. The installation of a collection center or containers for separate waste recovery will allow for cleaner and better extraction conditions. This improves the recyclability of post-consumption materials and brings the population closer to a mechanism that allows them to properly dispose of their waste and even receive money for its sale in these collection centers. These activities should not affect the state's finances.

8.4 Regulatory framework

Finding 12

The management plans promoted and required by local governments encourage the private sector to develop infrastructure for waste recovery. However, they are not very effective because they depend on the capacity of the plan's promoter; a joint effort is the most effective way to solve the waste management problem because it takes advantage of economies of scale and is not just one more procedure that must be complied with. This scheme should be used as a strategy for a solution based on a circular economy and with mixed, extended responsibility.

> **Recommendation 1.** Recognize existing national plans, implement them at the state level, adapting them to local conditions and ensure that they are applied by specific sector: for example, for plastic in the food, automotive or agricultural sectors, all actors should be organized in a single management plan scheme, in accordance with the principles of extended responsibility and with the participation of the government to influence the behavior of the population.
>
> **Recommendation 2.** Encourage the private sector to organize and present a model management plan that responds to national conditions and meets local interests, within the framework of the following points:

To have a technical-economic study showing the conditions of the available infrastructure for the waste stream of interest, and to indicate the necessary infrastructure for the adequate management of post-consumption waste, which facilitates its management and reincorporation into the economic circuits as a secondary raw material, co-product, or waste of thermal interest.

That it incorporates the aspects of product redesign, change of raw material, redesign of logistics and collection and handling equipment, remanufacture or repair for any type of plastic, and considers the behavior of garbage pickers and the population and covers national and regional objectives.

That post-consumption plastic waste has a high economic value to compete with that of virgin raw material, so that prices allow the establishment of a competitive secondary raw material market, with real and effective access to economic, fiscal or market instruments contemplated by the laws in force.

That all forms of recycling, recovery or use of waste, whether thermal, mechanical, chemical or any other type, are accepted, as long as they demonstrate that the resulting raw material is fully usable, does not leave waste in the process and is reintegrated into the manufacture of new products or is used as energy of any type.

> **Recommendation 3.** Establish a reliable, public and updated national registry of management plans and their degree of compliance as a key instrument to strengthen monitoring, oversight and transparency in waste management in Mexico. Currently, state and municipal registries are hampered by regulatory dispersion, duplications and

compliance gaps, which limits traceability and hinders comprehensive evaluation of the environmental performance of obligated actors.

Finding 13

Total bans have proven to be ineffective in the control and presence of plastics in the environment (all plastics impact the environment in different ways and magnitudes), but also voluntary schemes have proven to be ineffective, as only a few actors participate, when all contribute to the current situation of handling, management and economy of plastics.

Recommendation 1. Promote extended schemes of responsibility that are the next level of participation and coordination between the private sector and the government, but require that they consider existing management plans to have modifications, as well as general participation schemes where micro, small and medium-size entrepreneurs can participate without risking their financial and technical capacity and stability that would lead them to close their business, but instead allow them a correct management of post-consumption waste of any type of plastic.

Recommendation 2. Society must participate in a mandatory manner because consumers are the ones who own the waste and who have the option of disposal within their reach, for which the government and the private sector must make available to them the separation of plastic waste for recycling or chemical or thermal recovery, and the government, in turn, must apply the corresponding sanctions in accordance with the applicable law or regulation.

Recommendation 3. Recognizing that the participation of the private sector is an action of environmental justice, for which its collaboration and organized, standardized and proactive contribution in the management of plastics should be sought, a collaboration that contributes to the constitutional obligation of the municipalities in the handling, control, management and chemical, mechanical or thermal use of post-consumption plastic waste.

Recommendation 4. Strengthen training schemes and access to financing for entrepreneurs, micro and small businesses to improve and technically modernize their operations. These are improvements that can be achieved only through government, not the private sector.

Recommendation 5. In machinery and technology for recycling, industry is supplied by the international market, hence the convenience of the domestic market to become active in the manufacture of machinery and offer technology, equipment and its maintenance. This strategy can also be triggered by the government with technology transfer from allied countries, such as Germany, Denmark, Japan and Canada.

Finding 14

Implementing plans that have extended responsibility, although desirable, will still lack a strategy that recognizes the applicability of the instrument, the conditions and requirements for its implementation. To apply economic resources to waste recovery, the private sector requires mandatory, but standardized, nationally applicable and long-term schemes.

> **Recommendation 1.** Formulate the Extended Responsibility Act in coordination with the private sector, as it is the actor to whom this action will be applied. This act may include one or more ways of enforcing the extended liability obligation, which applies exclusively to plastic waste in general and is organized by application, i.e., food, electrical and electronics, automotive, agricultural, construction, and also that it be of national or regional application, and not local, with clear rules on aspects such as the establishment of costs, conditions, co-participating actors, mechanisms, oversight and administration, among others.

Finding 15

In response to local bans on single-use plastics, several states have issued their own environmental technical standards, which establish minimum recycled content rates or promote the substitution of natural or compostable materials. However, such regulatory fragmentation generates regulatory inconsistencies and hinders harmonization with international frameworks and will affect the sector's ability to demonstrate verifiable environmental compliance.

This lack of standardized national schemes hinders environmental differentiation and transparency in the composition of plastic products, limiting both competitiveness and traceability in the market.

> **Recommendation 1.** It is necessary to develop and implement a national environmental certification system that applies to plastic products, and especially with post-consumption recycled content.

9. Conclusions

9.1 Conclusions for Mexico

This section is composed of conclusions that delve into the implications and limitations of plastic recycling in the country, as well as key areas to strengthen it.

Recovery

The mixing of waste during collection, as happens in the collection vehicles of the cleaning system, causes a greater loss due to plastics contaminated with organic waste or with other liquids present in municipal solid waste or special handling waste. All of this impacts the recyclability of these wastes.

The participation of garbage pickers in collection vehicles and at final disposal sites, who extract a significant portion of plastic from general waste streams, has been analyzed only as a social problem, an informal activity unrelated to the fiscal problems faced by industrialists in the first purchase or the impact on sorting plants when receiving waste with little value and interest for material recycling. These are all aspects that need to be evaluated in more detail.

The collection centers are key players that, in addition to formalizing the plastics market, facilitate recycling by making a detailed selection, by type of material, of the recovered waste, although this activity also increases the prices of post-consumption waste for final recovery and recycling.

The recycling of post-consumption waste that was in contact with food is the most important consideration when recycling packaging from this sector. Other wastes may contain flame retardants, anti-statics, heavy metal additives, or hazardous chemical materials used in other applications, so their recycling is not suitable for incorporation into new food industry products.

Material purchase and sale transactions, which include from the garbage picker to all participants in the value chain, are carried out at commercial prices. If the waste has a good implicit economic value, i.e., a few units can complete a kilogram and bring a good market price, price guarantees are unnecessary to ensure the recovery of the materials.

Tax formalization in the recovery of plastic waste should occur at the time the garbage picker sells to the first purchaser, who must demonstrate to the tax entity that he acquires the materials from a formal source. But this situation rarely happens. Hence the need for better fiscal strategies and governmental support in this regard. It is likely that the registration of all garbage pickers and large unregistered collectors will allow for the recognition of the source of waste and unrestricted procurement by the first purchaser.

The collection centers are an infrastructure where the material is bought and sold at a commercial price; however, their functionality is questioned because the costs of the material increase with each change of level in the scale of collectors up to the recycler, which charges the material with a

cost overrun before even applying the recycling costs (separation, washing, shredding and pelletizing).

The large collectors or collection centers are the point in the value chain where the extraction of post-consumption plastic waste is formalized fiscally, and from them the activity can be regulated, and the origin and destination of the waste can be traced.

Large companies and brand owners have a value chain where suppliers are consistent and have a certain degree of loyalty, as well as a close relationship with garbage pickers or the population.

The obligation to install return points in management plans has proven to be ineffective when they are inside a store. Such points should preferably be associated with collection centers, which have proven to be the natural point of purchase and sale of plastic waste, although their effectiveness is closely related to plastic waste of economic value, i.e., it does not work for all plastic waste.

Recycling

In terms of apparent consumption—therefore, of TP resin waste generation—during 2022, PP was found in first place in the country, with 1,468 kt (22 percent of the total). In second place was LDPE-L, with 1,231 kt (18 percent of the total). Other resins, including engineering resins, recorded an apparent consumption of 1,135 kt (17 percent of the total), followed by HDPE with 1,116 kt (17 percent of the total), PET with 740 kt (11 percent of the total), PVC with 620 kt (9 percent of the total) and finally PS with 385 kt (6 percent of the total). In this sense, recovery and recycling strategies must be aligned and the corresponding investments and efforts must be applied to reduce their impact and improve their circularity.

According to the final industrial use of TP resins in Mexico during 2022, it was found that the category of conventional plastic uses is the most important, as 4,534 kt of TP resins were used in its production (68 percent of the total). In this category, the most important resins are PP, PE and PET due to their use in the production of packaging and other conventional uses. In second place is the category of uses in the production of electrical and electronic equipment, in which 903 kt of TP resins are used (14 percent of the total). In this category, engineering (other) resins are the most important because of their heat resistance, hardness, stiffness, etc. This is followed by the construction and demolition category, where 690 kt of TP resins were used (10 percent of the total), with PVC being the most important resin due to its use as a construction material. Finally, there is the use of plastic in the automotive sector, where 568 kt of TP resins were used (8 percent of the total). In the latter category, engineering resins (other) are also most commonly used.

It is paradoxical that the use of inks, the mixing of different types of plastic and contamination by labeling promote recycling through the production of black goods. This action makes it possible to homogenize the color and hide the differences caused by time, deterioration of the raw material or color changes; however, black post-consumption waste is difficult to recycle because the common infrared detection equipment used in the industry does not identify the different types of plastic in

black post-consumption waste. Generally, these materials are not recycled for the same product, so they end up in products with less technical and visual requirements.

In general terms, the authorities and society consider the impact of the garbage pickers to be positive, because the material is recovered in a clean manner and is high quality and the activity is carried out close to the source. The problem is that the sanitary conditions in which this activity is carried out, which are often deficient, unhealthy and risky for the people who perform them, have not been resolved.

A sorting plant that receives waste with little value for recycling and that is highly contaminated or dirty reduces the possibilities of recycling and requires continuous and constant investment that condemns it to be a white elephant, where the only viable destination of its waste is thermal utilization for energy generation. It would be advisable to transform these underutilized infrastructures into more profitable plants.

The activity of garbage pickers has collateral effects in the value chain, for example:

- It is an irregular activity that does not issue receipts or invoices, nor establish contracts.
- It is generally supported by public infrastructure, be it a collection vehicle, a container or a disposal site.
- It collects the waste with the highest market value, which influences the efficiency and financial balance or profitability of any sorting plant.
- It uses only the waste with value and leaves the rest of the materials free in the environment; this is the case of plastic from electrical and electronic equipment components, which is ignored while the most valuable metals are extracted.

Waste management

The public sector must generate conditions so that recyclable waste does not reach the FDS. The country must move forward in separation: from organic and inorganic waste to a more intense separation in accordance with the real needs of the environment, industry and society. Pre-established and organized planning must be followed, complemented by a correct operation and, above all, with effective follow-up and application—without distinction—of sanctions.

The main sources of income and economic resources of integrated waste management systems in advanced countries are the application of fees, the sale of recovered materials for recycling and the generation of electricity. In Mexico, the application of fees is practically nonexistent, and the cleanup systems lack sufficient economic resources to provide adequate integrated management services; there are also no incineration plants, and waste of material value is separated by actors independent of those responsible for the collection of municipal solid waste and special handling waste.

At sites classified as CSi and UCSi, plastic waste recovery is usually carried out in very precarious conditions, and the recovered material does not present the best conditions for recycling because

it is contaminated with other waste that gives it odor and color, in addition to the weathering that made it brittle. The material that presents evident odor and weathering is no longer useful, its recovery for recycling becomes practically impossible due to the high costs of washing and the use of sophisticated technology to clean it, although its high caloric value recommends it for the substitution of fossil fuels in incineration plants. These are materials that can always be used in a strategy of national benefit.

Recycling infrastructure starts with planning a reliable diagnosis for the generation and composition of solid waste in the country's municipalities and knowing how much of this waste is reaching the FDS. However, there are very few studies of generation and composition in Mexico, so their implementation should be strengthened. A recommended period for this is every ten years, based on a standard that considers current requirements and standardizes the development of these works: considering the different conditions in which waste is generated, handled, recycled and disposed of in Mexico.

There are states that, due to the size of their population, require more or better infrastructure for waste management and utilization, such as Estado de México, Puebla, Guanajuato, Chiapas and Oaxaca. However, having more infrastructure or the best technology does not necessarily mean better management. Some metropolises such as Mexico City have made important efforts to improve the recovery of their waste through the construction of new sorting plants and the promotion of innovative technologies, without forgetting that the city does not have final disposal sites and that its proper waste management allows it to have little free waste on public roads, and with all this, it suffers from flooding due to the presence of waste.

The granting of compensation or a gift (products or money) for the delivery of waste increases recovery, is not effective over time and is subject to total dependence on allocated budgets or agreements between the government and some private parties. This limits the environmental responsibility of the population, and the data demonstrate a recovery that, in addition to being limited, does not solve training problems or improve operations at scale.

An important element to improve the cleanliness of post-consumption waste is containerization in urban, rural or even Indigenous areas, as it is an infrastructure that facilitates the activity of garbage pickers and, although informal, supports the recovery and recycling scheme, mainly of PET, PP, HDPE and LDPE.

Regulatory framework

The increase in local regulation, which prohibits commercialization in the different states of the country, presents several discrepancies, as follows:

- There is no homologation between national and local regulations, which causes private investment to be greater, since the regulatory conditions and procedures, largely due to the required labeling, lead to the development of exclusive products for application in a single state.

- Regulation, in the absence of generalized or at least regional application, causes an exchange of goods and services between states that dilutes or minimizes the effect of restrictive actions by one locality on the other.
- Bans have not reduced the production of single-use plastics, and public infrastructure has not grown to address the problem. The only thing that has increased is the presentation of management plans, but on a company-by-company basis, which disintegrates economic efforts, confuses messages and gives preference to dissemination schemes rather than volume recovery and recycling.

Management plans or strategies with national coverage allow stakeholders to standardization their efforts but require local recognition. In their current structure, they lose effectiveness as they are considered voluntary instruments or only a formality. With some modifications, this instrument can become a compliance option in extended responsibility schemes, take advantage of economies of scale and various technological options for chemical, mechanical or thermal recovery, and socialize the participation of the industry with the reduction of inequality in financial and operational aspects.

The prohibitions have been applied in a differentiated manner, with special focus on self-service stores, convenience stores, department stores and large brands. This differential application of sanctions and prohibitions discourages and then encourages non-compliance with regulations.

The following table was taken from the plastics studies for Canada and the United States, already mentioned in this study, and published by CEC; we have retained their original structure to facilitate the relationship of these barriers and actions—mainly in terms of human, material and financial resources—with the elements identified in this study for Mexico.

Table 36. Barriers to circularity and solutions – Plastics Waste Management in Mexico

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
There are not enough funds for a comprehensive management of waste that covers recovery, management, operation and final disposal.	Unsustainable financing practices without the system generating its own financial resources. Local governments decide to apply the resources available from the allocated budget and what they are able to obtain from national or international financing programs.	Development and application of differentiated fees for collection and cleaning services, allowing for the financial balance of the system and considering socio-cultural differences in its application.	Work with local governments to manage application of unified rates throughout Mexico that take local needs into account and respond to the socio-cultural conditions of each state or municipality.

			
Barrier to circularity	**Possible cause**	**Suggested solution**	**Actions for policy makers**
	A vision of public infrastructure with no return on investment, which does not have sufficient resources for its operation and maintenance, nor does it recover the economic value of the waste.	Implementation of schemes to recover the economic value of waste with investment from the federal or international government and for the benefit of the system itself. Use integrated generator control and monitoring systems.	Ensure that the investment projects that already consider capital return studies are real and are carried out, with the development of control, surveillance and sanction mechanisms for cases of noncompliance.
Infrastructure is irregular and insufficient in many of the country's municipalities	The technical and economic capacities of the municipalities are unequal and do not allow the construction of the minimum infrastructure for waste management.	A National Waste Commission could help to standardize the infrastructure for waste management, which in its first years could provide technical support to municipalities that have not developed this capacity.	The design and creation of a National Waste Commission with the functions of technical support in the short term, guarantor of investment projects with total control in the medium term and, in the long term, an operating agency with presence in each state. This allows inequality to be reduced and ensures sufficient resources and infrastructure for waste management.
	There is no infrastructure that enables waste recovery and management in rural areas with large populations of Indigenous people.	When there are sufficient communication routes, install collection centers or containers that function as transfer stations with an adequate frequency of collection. This could be sufficient to maintain the environmental and social health of the municipalities.	Design and support the implementation of each project in areas with no infrastructure, and analyze the material elements necessary to implement the project, based on communication routes.

9.2 Shared Conclusions on Plastics Waste Management in Canada and the United States

In December 2024, the CEC published a study and its respective executive summary on this waste stream for Canada and the United States.[2] Both documents include a section dedicated to barriers to recycling the waste stream that is the subject of this document. With regard to Mexico, it can be concluded that these barriers have significant similarities and are shared with those identified in the other two countries.

In particular, Mexico has additional barriers, which are included in this section. Once the information corresponding to the country has been identified, it is important to comment that there are states, municipalities or large producers that can implement the recommendations made by Canada or the United States, without neglecting the issues mentioned in the findings and recommendations section of this study.

The recommendations and barriers identified in the studies conducted in Canada and the United States are presented below, preserving their original structure but adapting them to the issues that directly affect the Mexican context.

In these studies, barriers to circularity are grouped by plastic use application: packaging, construction and demolition, automobiles and electronics.

For some barriers there are multiple possible causes, with their own suggested solutions and corresponding policy recommendations. In such cases, the following tables are structured using separate cells and color coding for clarity.

The color code is red for the two columns on the left describing the challenges and barriers to circularity, and green for the two columns on the right with suggested solutions. At the top of each table, the flags of Canada, the United States and Mexico are used to indicate to which nation it applies.

It should be noted that there is some repetition in the content of the tables. This is because there are multiple reasons for barriers to circularity, and public policy actions can serve as solutions to overcome more than one barrier.

In Tables 37-40 below, the texts in the original English version of the Canada/US study prepared for the CEC are presented in italics. When the content corresponds specifically to the wording

[2] The executive summary in Spanish and the full technical study in English are available at the following links:<www.cec.org/es/publications/oportunidades-en-relacion-con-el-manejo-de-residuos-de-plastico-en-canada-y-estados-unidos/> and <www.cec.org/publications/milestone-study-on-plastics-waste-management-in-the-us-and-canada-2/>.

applicable to Mexico as well, it is shown in italics and bold type. When barriers, causes or solutions are relevant only to Mexico, the text is presented in normal font and bold.

The most commonly presented public policy recommendations include:

- **Extended producer responsibility** (EPR) is an environmental policy approach in which producers assume financial responsibility for managing the packaging they place on the market at the end of its useful life. This can be used to promote circularity in a number of ways, including the introduction of collection and recycling targets, the modulation of EPR product fees to incentivize the inclusion of recycled content and design for recycling, as well as the use of EPR funds to finance investments in infrastructure, education and outreach.
- **A deposit return system** (DRS), also called a "container deposit system," "refund deposit" or "bottle bill," places a monetary deposit on a product, paid by the consumer at the time of purchase, which is refunded when the consumer returns it to a designated location for reuse or recycling. Approving a DRS in jurisdictions where no others exist can help increase the volume of plastic bottles collected in the country and therefore improve the availability of high quality recycling raw material. The DRS also tends to lead to better numbers due to better tracking of marketed products.
- **Recycled content targets** could help reorient the plastics value chain away from its historical reliance on virgin plastics toward the use of more recycled material. This would provide recyclers with a clear market signal by creating demand and stable prices for recycled plastic. They can also be used to drive innovation and overcome challenges related to some difficult-to-recycle plastics, such as flexible films. As such, a first step would be to assess the extent to which recycled content could be applied to different packaging materials, then set ambitious but achievable targets and, finally, legislate minimum recycled content requirements to increase demand for recycled plastics.
- There are **other objectives**, beyond recycled content, that can help move the plastic packaging industry toward circularity. This includes targets to reduce plastic sources, reuse single-use plastic packaging and reduce virgin fossil-based plastics in packaging. Almost all objectives could be part of extended producer responsibility or introduced as separate policies, depending on how they fit into the legislative context.

Table 37. Barriers to circularity and solutions in the three countries - Packaging

			
Barrier to circularity	**Possible cause**	**Suggested solution**	**Actions for policy makers**
High disposal rate of plastic packaging compared to recycling: *In the United States and Canada, due to low recycling rates, 20.6 million tons of plastic packaging material is disposed of rather than recycled.* **For Mexico, 5,012 kt of packaging is disposed of instead of being recycled.**	*Single-use design:* *Most plastic packaging is designed for single-use applications. The resulting plastic waste often ends up in linear pathways (i.e., not circular, not recycled or reused). This problem is aggravated by improper disposal by consumers and poor landfill management.*	*Replace single-use packaging with reusable packaging whenever possible to reduce the need to manage single-use packaging waste.*	*Conduct a survey to identify where and in what contexts (e.g., food and beverage, online shopping, delivery, packaging) reuse is being used and tested. Where appropriate, establish public-private partnerships to invest in reuse infrastructure (e.g., washing facilities, collection systems, etc.), zero waste packaging stores and pilot projects.*
			Investigate appropriate targets for plastic source reduction and reuse of single-use plastic containers and food service utensils. Where appropriate, establish these objectives.
			Integrate reuse requirements and funding into state EPR and reimbursement deposit legislation.
			Identify the types of packaging for which bans or taxes would be appropriate measures (making sure to consider the impact of substitute materials).
			Identify the types of packaging that would benefit from grant programs for reuse or refill projects.
			Conduct a study to review and evaluate current reuse standards. Then identify needs and recommend or

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
			develop standards, where appropriate.
			Develop regulation that encourages reuse while protecting liability.
Limited availability of recycled plastic: *Insufficient quality and quantity of recycled plastic for repackaging means that reliance on virgin plastic remains high. The demand for this material is greater than the supply.*	*Insufficient quality and quantity of recyclable material and a volatile market can hamper the recycling industry and limit the production of recycled plastic:* *Problems with the collection of clean and recyclable plastics lead to insufficient quality and quantity.* **In Mexico, mixing waste during collection results in a greater loss of plastic waste with recycling potential.**	*Increase volume and quality of recycled plastic to turn it back into packaging.*	*Develop policies to encourage and enable increased recycling activities, including improved collection and sorting.*
			Consider investment and pilot projects to accelerate chemical recycling technology targeting plastic waste not suitable for physical recycling.
			Assess where and to what extent recycled content could be applied to different packaging materials, then develop targets and legislate minimum recycled content requirements to increase demand for recycled plastics.
		Consider investment and pilot projects to accelerate chemical recycling technology targeting plastic waste not suitable for physical recycling. *Consider investment and pilot projects to accelerate chemical recycling technology targeting plastic waste not suitable for physical recycling.*	*Consider investment and pilot projects to accelerate chemical recycling technology targeting plastic waste not suitable for physical recycling.*
			Assess where and to what extent recycled content could be applied to different packaging materials, then develop targets and legislate minimum recycled content requirements to increase demand for recycled plastics.

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
			Consider investment and pilot projects to accelerate chemical recycling technology targeting plastic waste not suitable for physical recycling.
			Assess where and to what extent recycled content could be applied to different packaging materials, then develop targets and legislate minimum recycled content requirements to increase demand for recycled plastics.
Limited use of recycled plastic in comparison to the high use of virgin plastic: *Negative environmental and social impacts are associated with the increasing quantities of virgin material used for packaging. Use of recycled content is limited to a small number of applications and in relatively small quantities.*	*Recycled plastic poses more challenges compared to inexpensive virgin plastic:* *Virgin plastics are relatively inexpensive and lightweight materials that are widely used in packaging.* *Volatile markets make the recycling industry less attractive to potential investors. When oil prices are high, so are virgin plastic prices, and recycled plastic can be more competitive. But when virgin plastic prices drop, they can compete with recycled plastic. This can lower the price of secondary plastic material, making the recycling industry less profitable.*	*Optimize plastic packaging design to eliminate unnecessary different types circulating in the market.*	*Investigate and pass legislation requiring headspace reduction (i.e., reducing the empty space inside packages) and correct sizing for all packages.*
			Pass legislation to reduce plastic wrap (i.e., plastic film covering products such as produce, meat or soft drinks, for example) by requiring that it be used only when "necessary" and that it be reduced wherever possible.
		Increase the volume and quality of recycled plastics.	*Develop policies to incentivize and enable greater recycling activities, including improved collection and sorting.*
			Consider investment and pilot projects in chemical recycling technology aimed at addressing plastic waste not suitable for physical recycling.
			Evaluate the success of taxes on virgin plastic in

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
			other jurisdictions and assess their suitability.
			Evaluate where and to what extent recycled content could be applied to different packaging materials, and then develop targets and legislate minimum recycled content requirements to increase demand for recycled plastics.
			Develop a Canadian, US and Mexican standard to enable cross-jurisdictional alignment in the measurement of recycled content.
			Set targets and transition packaging to increase the use of recycled content. This would support industry with the standardization of recycling specifications (e.g., those currently being developed by the Alliance to End Plastic Waste) and liaison with the European Committee for Standardization (CEN) on standards being reviewed and developed in Europe to support the European Strategy for Plastics in the Circular Economy.
		Increase the use of sustainable, recyclable, bio-based and non-biodegradable packaging. *Improve consumer recycling behavior*	*Research and set targets for the reduction of virgin fossil plastics in packaging. This could be part of the EPR or separate legislation, as appropriate to the legislative context, and be carried out in conjunction with the recommendations of CEC's*

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
		through better education.	*bioplastic waste and paper waste studies.*
		Create accurate and consistent labeling.	*Review and evaluate the success of taxes on virgin plastic in other jurisdictions and assess the appropriateness of such taxes.*
		Harmonize or standardize the materials that can be recycled in a region or jurisdiction to mitigate consumer confusion.	*Develop policies to encourage and improve collection rates and reduce pollution.*
			Invest in and create pilot projects to develop collection systems for flexible films and other plastic waste that are not historically targeted by physical recyclers but are a growing raw material for chemical recycling.
		Increase the use of sustainable, recyclable, bio-based and non-biodegradable packaging.	*Initiate collaborative discussions with stakeholders on labeling consistency.*
			Pass a federal law requiring accurate and transparent recyclability claims on product labels (e.g., updates to the FTC Green Guides).
Low quality of plastics collected for recycling due to contamination	*Inconsistent recycling requirements in different jurisdictions:*	*Improve consumer recycling behavior through better education.*	*Research and development to improve resin identification code (RIC) labeling to avoid confusion.*

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
	Inconsistent recycling requirements in different jurisdictions (even at the subnational level) have led to confusion among consumers as to which items are recyclable. This inconsistency also poses challenges in creating uniform messages or labels, either on product packaging or waste containers, to educate consumers about proper disposal options and recycling practices.	*Create accurate and consistent labeling.* *Harmonize or standardize the materials that can be recycled in a region or jurisdiction to mitigate consumer confusion.*	*Increase enforcement to incentivize proper recycling (e.g., fines for improper disposal).*
Limited data availability: **In Mexico, data are limited on end-of-life treatment of plastics and the processing capacities of facilities, which means that there is a lack of detailed information on the tonnages of different materials in circulation entering the waste stream versus escaping into the environment, and the material flows within waste streams, including how they are finally processed.**	*Lack of standardized waste reporting requirements:* **Standardized and minimum waste reporting requirements are lacking in Canada, the United States and Mexico. In addition, incentives to report data are lacking.** **In addition, often little data are available on the informal sector, which is especially active in parts of the United States and Mexico.**	*Implement waste characterization standards in the three countries.*	*Develop guidance and potential incentives for waste reporting and guidance on conducting waste characterizations.*
		Implement extended producer responsibility.	*Encourage extended producer responsibility, under which producers would be required to report sales and yield data.*
		Implement deposit return systems (DRS) in more areas.	*Support enactment of DRS in more states or nationwide. Generally, DRS leads to better data due to better tracking of products placed on the market along the waste value chain. In addition, it is necessary to ensure that DRS operates according to the same core bill of materials to increase standardization of waste management.*

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
Minimal recycling of multi-material flexible plastics: *There is currently a minimal recycling rate of multi-material flexible plastics.*	***Lack of infrastructure for sorting and processing flexible multi-materials:*** *There is a serious lack of infrastructure for sorting and processing multi-material flexible plastics, specifically that which can process them without facing contamination problems.*	*Encourage source reduction by implementing a ban on multi-material flexible plastics for packaging where a more circular alternative exists.*	*Conduct a study on which multi-material flexible plastics are most problematic and what alternatives could be used if a ban were to be implemented.*
		Improve product design to facilitate recycling.	*Establish design requirements for flexible films that enable easier sorting and recycling (e.g., single-material flexibles).*
			Support and increase research and development grants for improved packaging design for recyclability.
		Increase infrastructure that can sort and process multi-material flexible plastics.	*Invest in technology, research and development and pilot facilities.*
			Encourage federal leadership in defining chemical recycling to standardize the industry.
Low recycled content in food grade packaging: *Relative to other packaging, there is a particularly low use of recycled content in food grade packaging.*	***Lack of adequate raw materials:*** *There is a lack of infrastructure that can produce food grade recycled resin outside of PET bottles, as the quality of the material feeding these processors is not pure enough.*	*Provide guidance to industry on what technology or production methods can achieve food grade recycled content.*	*Work with industry to meet requirements for food-grade recycled content (along with bioplastics).*
		Increase the infrastructure that can create food-grade recycled resin.	*Encourage investment and pilot studies in food-grade recycling technologies.*

			
Barrier to circularity	**Possible cause**	**Suggested solution**	**Actions for policy makers**
Unreliable comparisons between jurisdictions: *Lack of clarity on how recycling rates compare between jurisdictions.*	***Lack of a consistent methodology for measuring recycling rates or recycled content:*** *There is no consistent methodology for measuring recycling rates or recycled content in Canada, the United States and Mexico.*	*Publish standard guidance on how recycling rates and recycled content should be calculated in North America.*	*Initiate collaborative discussions on calculation methods for recycling rates and recycled content with actors.*

Table 38. Barriers to circularity and solutions in the three countries - Construction and demolition

			
Barrier to circularity	**Possible cause**	**Suggested solution**	**Actions for policy makers**
Increased use of virgin plastic in construction: *In Canada and the United States, increasing amounts of fossil fuel plastics are being used in building materials.* **In Mexico, all plastic used as construction material is of fossil origin.**	***Plastics are generally lower in cost than alternative building materials:*** *Plastics are a relatively inexpensive and lightweight material that is increasingly being used in construction.*	*Increase the use of plastics with recycled content instead of virgin fossil fuel plastics.*	*Invest in research and development and pilot projects focused on increasing the use of recycled content plastics in construction.*
		Increase the use of sustainable, recyclable, bio-based and non-biodegradable substitutes.	*Invest in research and development and pilot projects focused on increasing the use of bio-based plastics in construction.*
Minimal reuse of construction and demolition plastic waste: *There is low reuse of construction and demolition plastic waste relative to other types of plastic waste.*	***Difficult to separate plastic in construction and demolition waste from other mixed materials.***	*Encourage design for disassembly.*	*Incentivize (e.g., with tax breaks) construction plans that incorporate EOL considerations into their plans.*
			Research and development of construction methods that allow easy classification of EOL, even for plastic components. Engage value chain actors in pre-competitive collaboration to

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
			understand EOL usage needs and options.
		Require source separation at the site.	*Establish requirements for separation at source of materials for reuse and recycling at construction and demolition sites.*
	***Difficult to store** building materials used for long periods of time due to their large size.*	*Increase storage of construction materials.*	*Provide grants for local construction resource reuse centers, which store and sell used construction materials, to enable storage and reuse.*
	***It is difficult to access used materials from other construction projects** due to the size, project timelines and lack of knowledge of what materials are available.*	*Facilitate connection or accessibility to reusable plastic materials to encourage adaptive reuse.*	*Support and invest in reuse networks that provide a centralized online database of what materials are available and their status and location.* **For Mexico, consider construction industry management plans and local regulations for construction and demolition waste recycling.**
	***Potential liability or material condition concerns** regarding structural integrity that increases friction for reusing plastic materials in construction.*	*Create a standard or verification system that gives the industry confidence in the reuse of plastic material.* ***For Mexico, consider construction and demolition waste, and local regulation for recycling of debris.***	*Clarify, first, materials testing standards for reuse and then accountability around the use of second-hand materials in construction.*
***Low recycling rate of plastics from construction and demolition waste** compared to other*	***Difficult to separate for recycling:*** *Plastic in construction and demolition debris is*	*Encourage design for disassembly, which would facilitate the separation of waste*	*Incentivize (e.g., with tax exemptions) construction plans that incorporate end-of-life (EOL) considerations into their plans.*

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
categories of plastic waste.	*often difficult to separate from mixed materials.*	*into specific material streams.*	*Provide grants for research and development of construction methods that allow easy classification of EOL, including plastic components.*
	Lower value of plastic materials: *Plastic has little value compared to other materials, such as metals. In addition, some plastics used in construction release dioxins or deteriorate at the end of their useful life, further reducing their value.*	*Require on-site separation of materials, which reduces sorting loss rates and increases the quality of the waste stream, i.e., less material is lost to contamination.*	*Establish requirements for source separation of materials for reuse and recycling at construction and demolition sites.*
		Increase the demand and price of recycled plastic in construction.	*Implement, whenever possible, taxes on the use of virgin plastic for construction. On an ad hoc basis, for parts that do not require custom structural specifications for plastic.*
			Implement minimum recycled content requirements to increase demand for recycled plastics.
			Conduct a study to examine alternatives to toxins used in construction that reduce the value of EOL plastic used in construction and demolition.

Table 39. Barriers to circularity and solutions in the three countries - Automotive

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
Increased use of virgin fossil fuel plastics *in the automotive sector.*	***Plastics are lightweight, which improves fuel efficiency:*** *Replacing heavy materials, such as metal, with plastic can reduce the weight of vehicles, which improves fuel efficiency and reduces emissions.*	*Increase the use of plastics with recycled content instead of virgin fossil fuel plastics.*	*Incentivize (e.g., with tax exemptions) the design of automobiles that meet recycled content requirements.*
			Offer grants for research and development for designs that include recycled plastics in the manufacture of automobiles.
		Increase the use of sustainable, recyclable, bio-based and non-biodegradable substitutes.	*Incentivize (e.g., with tax exemptions) the design of automobiles that meet bio-based targets.*
			Offer grants for research and development in the use of bio-based plastics in automotive manufacturing.
	Increase in individual car ownership: *A secondary concern is the number of vehicles in Canada, the United States and Mexico, which is growing as private car owners also increase.*	*Improve public transportation to reduce reliance on private car ownership and production, thereby reducing materials (including plastic) used in the automotive industry.*	*Invest in expanding and improving public transportation systems.*
		Support the collaborative economy for vehicles to reduce reliance on private car ownership and production, thereby reducing materials (including plastic) used in the automotive industry.	*Pass policies (e.g., with tax exemptions) that support carpooling, ridesharing, etc. (e.g., cabs, Uber, DiDi).*

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
Low recycling rate *of plastics in the automotive sector.*	***It is difficult to separate*** *some of the plastic inside the vehicles from the mixed materials.*	*Designing for deconstruction.*	*Incentivize (e.g., with tax exemptions) automobile design that incorporates EOL or end-of-life considerations.*
			Offer grants for research and development in design aimed at deconstruction improvements.
	Costs associated with deconstruction: *Not all vehicles are deconstructed prior to shredding, as it is often more cost effective and less labor intensive to shred vehicles instead of breaking them down.*	*Increase access to deconstruction locations prior to crushing.*	*Investigate capacity and needs for deconstruction facilities and infrastructure for end-of-life vehicles.*
	Sorting is minimal*: most of it is converted into ASR (Automobile Shredder Residue).*	*Improve ASR plastic recovery.*	*Investigate (e.g., possible use of current technology or development of new technologies and tests) how to improve the recovery of plastics from ASR.*

Table 40. Barriers to circularity and solutions in the three countries - Electronics

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
Increased use of virgin fossil fuel-based plastics *in electronics.*	***Plastics are relatively inexpensive and lightweight:*** *Plastics are a relatively inexpensive and lightweight material used in many types of electronic products.*	*Increase the use of plastics with recycled content instead of virgin fossil fuel plastics.*	*Incentivize (e.g., with tax exemptions) electronic products that meet recycled content requirements.*
			Offer grants for research and development in design using recycled plastics in the manufacture of electronic products.

Barrier to circularity	Possible cause	Suggested solution	Actions for policy makers
		Increase the use of sustainable, recyclable, bio-based and non-biodegradable substitutes.	*Incentivize (e.g., with tax exemptions) electronic products that meet bio-based objectives.*
			Offer grants for research and development in the use of bio-based plastics in electronics.
***Increased frequency of consumption** of certain electronic devices.*	***Short useful life of product:*** *Some electronic devices are not designed to last a long time, but to be replaced every two or three years.* *For some products, such as cellular phones, producers encourage annual upgrades (e.g., with discounts, promotions, etc.).*	*Design products with a longer useful life, allowing for reuse and reconditioning.*	*Offer grants for research and development in electronic design for longer service life and repairability.*
			Implement an obsolescence ban designed for certain products.
		Limit unnecessary upgrades and similar promotions.	*Conduct or commission a study on the impacts of promotions and incentives around unnecessary electronics upgrades.*
	Barriers to repair: *Inaccessible repair due to proprietary parts, tools, etc., that limit who or what organizations can make repairs.*	*Increase access to repair.*	*Pass and support right-to-repair legislation (establishing that consumers and independent repairers have the right to obtain manuals, diagrams, diagnostics and parts from OEMs to repair their own devices).*
***Difficult to separate parts**, including plastics, for many electronic products.*	***Not designed for recycling:*** *Many electronic products are not designed to allow for easy and efficient disassembly, sorting and recycling or reuse of parts.*	*Increase the efficiency of electronic waste sorting.*	*Offer grants for research and development in sorting technology to improve sorting speed and efficiency and repairability or reusability.*
			Incentivize (e.g., with tax exemptions) electronic products that incorporate end-of-life considerations.
			Conduct a study to identify incentives and policies to

			
Barrier to circularity	**Possible cause**	**Suggested solution**	**Actions for policy makers**
			increase the reuse of second-hand material parts in reconditioned equipment.

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