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Milestone Study on Plastics Waste Management in the US and Canada

Transforming Recycling and Solid Waste Management in the US and Canada

Executive Summary

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* Photo credit – Cover: Planters made of recycled plastic bottles by Elizabeth Romo-Rabago from Ciclomanias. https://www.ciclomanias.com

1 Study Context and Scope

The CEC has commissioned this study as part of its Operational Plan 2021 Project "Transforming Recycling and Solid Waste Management in North America"[1], with the goal of promoting circular economy and sustainable materials management approaches and bring economic and environmental benefits to the region. The project supports Canada, Mexico and the United States in their efforts to promote circular economy and sustainable materials management approaches to encourage eco-design and thus increase product and material reuse, recovery, and recycling rates.

This publication represents one of a series of three milestone studies which aim for better understanding of the opportunities in the recycling sector and secondary material markets for plastics, paper, and bioplastics waste. The content focuses on the US and Canada, and a separate set of these studies focused on Mexico will be available in the upcoming months. Building on the results of these milestone studies and on stakeholder input, the project will carry out pilot testing projects in a second phase designed to assess the feasibility of innovative technologies, policies, or practices for adoption at scale across North America.

The following report is the milestone study on plastics waste (bioplastics and paper waste are covered by separate publications). It presents, in terms as comprehensive as the available data allow[2], a picture of the current state of plastics circularity, the barriers to further circularity, and opportunities for overcoming these barriers. Information presented in this study is designed to support stakeholder collaboration and knowledge-sharing and provide policy makers with evidence-based recommendations for improving plastics waste management and circularity in Canada and the US. It does this by examining the state of play along the plastics value chain in both countries, including sustainable product and packaging design, difficult to recycle plastics, recycling and recovery markets, secondary materials markets, and current and proposed policy and regulation related to plastics. It also considers best practice, emerging technologies, and policy options deployed elsewhere in the world.

The scope of this milestone study is post-consumer plastics waste from residential and commercial sources. Packaging is a significant use market for plastics, but three-quarters of all plastic used in 2018 went into other markets, including construction, automotive, electronics, agriculture, textiles, and more. In this study, we have focused on the four largest applications of plastics in Canada and the US by tonnage: packaging, construction and demolition, the automotive industry, and electronics. The specific categories of plastics and applications in which they are used are depicted in Figure 1.

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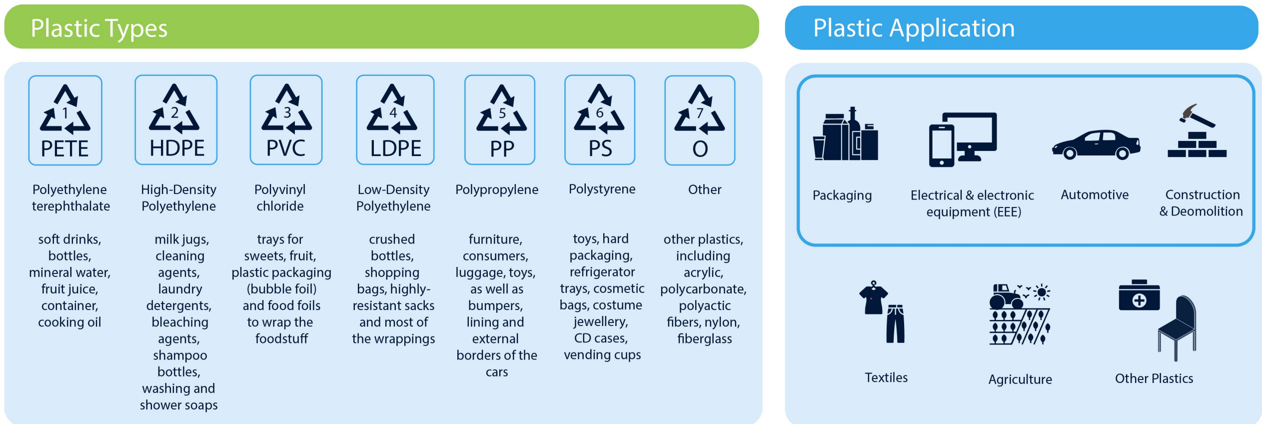
[1] CEC Operational Plan 2021 Project. "Transforming Recycling and Solid Waste Management in North America."

[2] This study considers the information and data available by December 2023.

Figure 1. Types of plastics and their common applications



Source: Eunomia Research & Consulting

2 Research Method

The information presented in this milestone study was gathered through secondary, desk-based research, analyzing existing relevant publications and databases, and primary research through consultation with key stakeholders in plastics waste management in each country. A wide range of sources were used, ranging from international databases provided by the United Nations (UN) to state- and provincial-level responses to requests under the US Freedom of Information Act (FOIA) and the Canadian Access to Information Act (ATIA).

Based on the available data, a methodology was developed to generate a material flow for plastics products in Canada and the US. The methodology enabled plastics waste to be traced throughout the supply chain, from the production and consumption of plastics products through to the collection, sorting and reprocessing of plastics waste. At each stage of the process, the losses from the system were quantified. The purpose of this analysis was to establish a baseline from which policy makers, service providers, operators, and investors can make informed strategic decisions on what measures are needed in the short-, medium-, and long-term to support a circular economy, replace virgin material consumption in production with secondary materials, and reduce greenhouse gas (GHG) emissions.

Throughout the report, where available, relevant market data and policy information are provided for individual federal states in the US and provinces/territories in Canada.[3]

[3] There are 50 federal states in the United States. Canada is composed of 10 provinces and three territories.

3 Key Findings

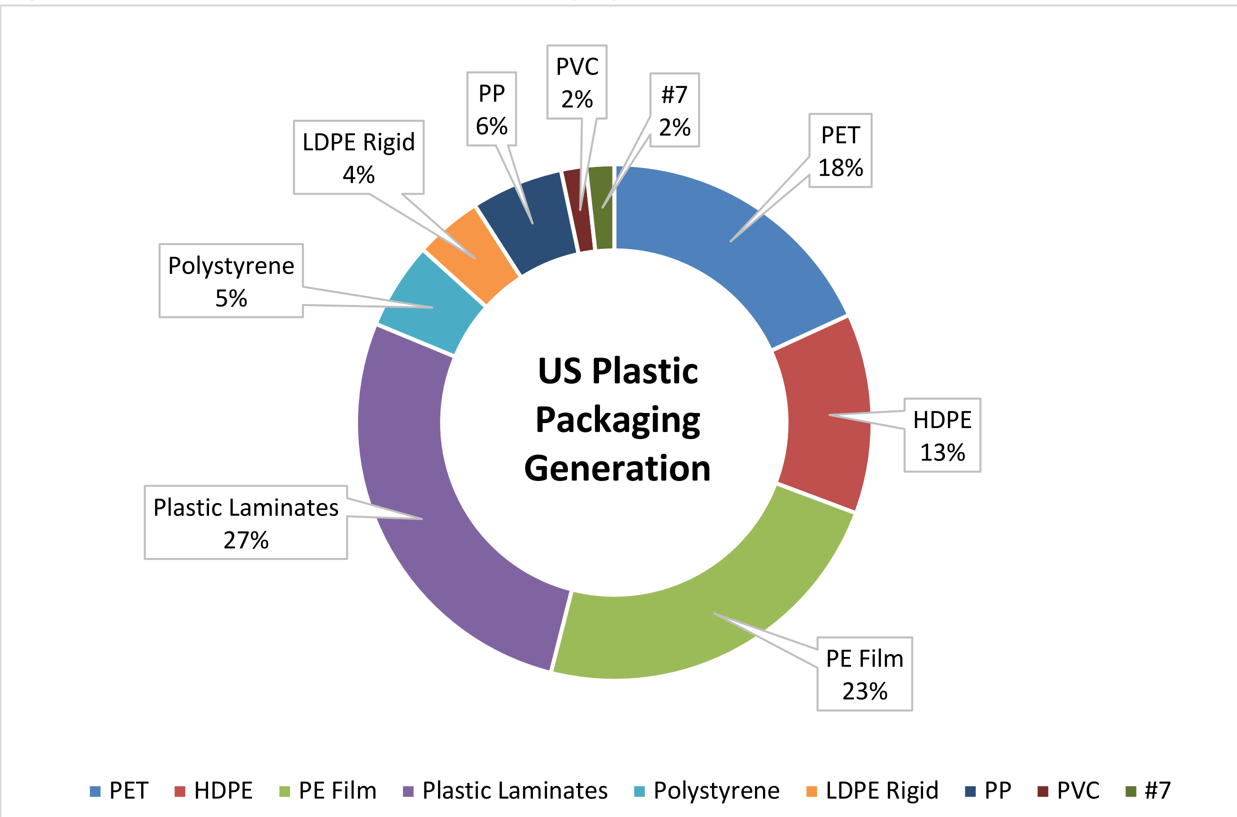
For the purposes of this study, we have focused on the four largest applications of plastics in Canada and the US by tonnage: packaging, construction and demolition, the automotive industry, and electronics. The following section summarizes findings for packaging and single-use plastics, while the market overview for plastics waste from construction and demolition, the automotive industry, and electronics is summarized in section 3.2.

3.1 Material Flows and Waste Management: Packaging

United States

In 2021, approximately 20.8 million tonnes of plastic packaging waste were generated in the US. The breakdown by resin is shown in Figure 2 below. Plastic laminates, also known as multi-resin and multi-material plastics, have the highest share (27%) of plastics waste generation in the US. This category includes multi-resin and composite films. PE film is the second-largest category (23%) in terms of quantities of plastic generated. The largest category of rigid plastic is PET (see Figure 1) at 18% (3.8 million tonnes), followed by HDPE at 13% (2.6 million tonnes).

Figure 2. Resin composition of plastic packaging in the US (2020)

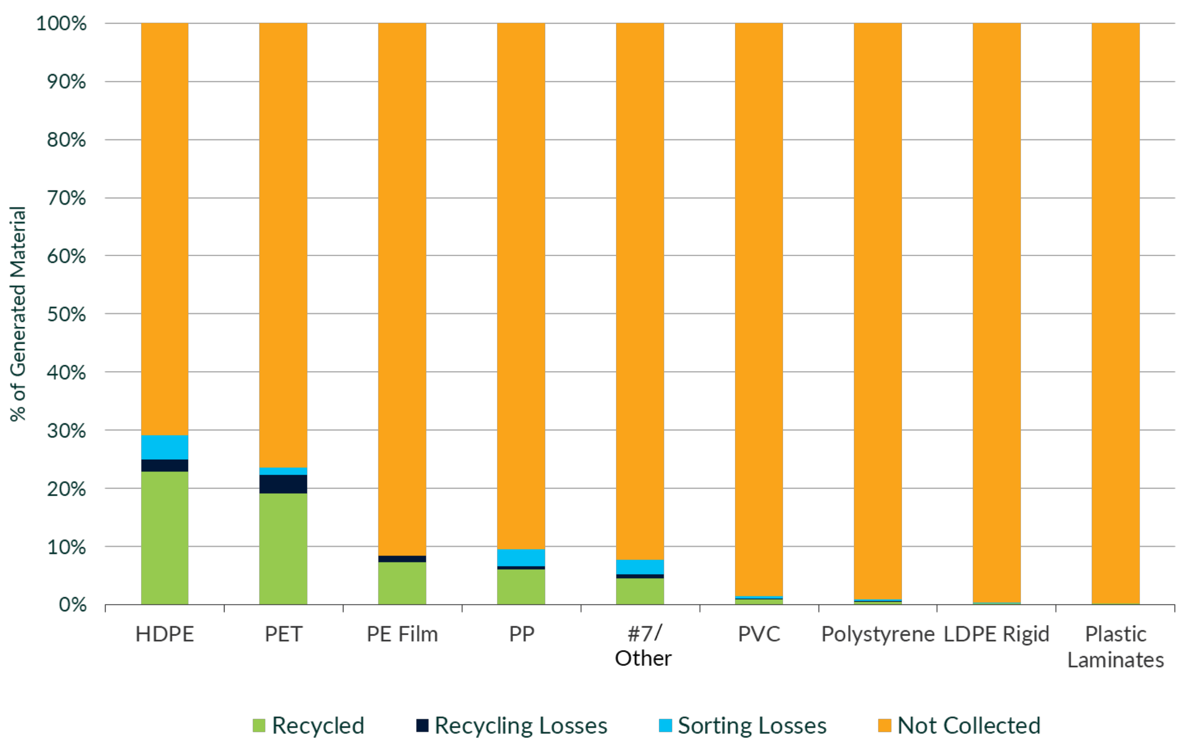


Source: Eunomia Calculations, EPA Data, (Eunomia, 2021), (Stina Inc., 2020), (Sustainable Packaging Coalition, 2021)

Of the plastic packaging waste generated, approximately 2.2 million tonnes were collected for recycling, yielding a recycling collection rate of 11%. Plastic waste that is collected from residential sources via a curbside system must then be sorted from other recyclable material at a materials recovery facility (MRF) before it is baled and sent to a recycling facility.

Figure 3, below, shows the fate of plastic material at different stages of the waste management system, including tonnage not collected for recycling, tonnage lost at the sorting stage, tonnage lost at the processing stage, and lastly the percentage of each resin which is reprocessed. Across all plastic packaging types, the majority (nearly 90%, over 18 million tonnes) of plastic packaging waste was not collected for recycling, representing the first limiting factor to domestic circularity.

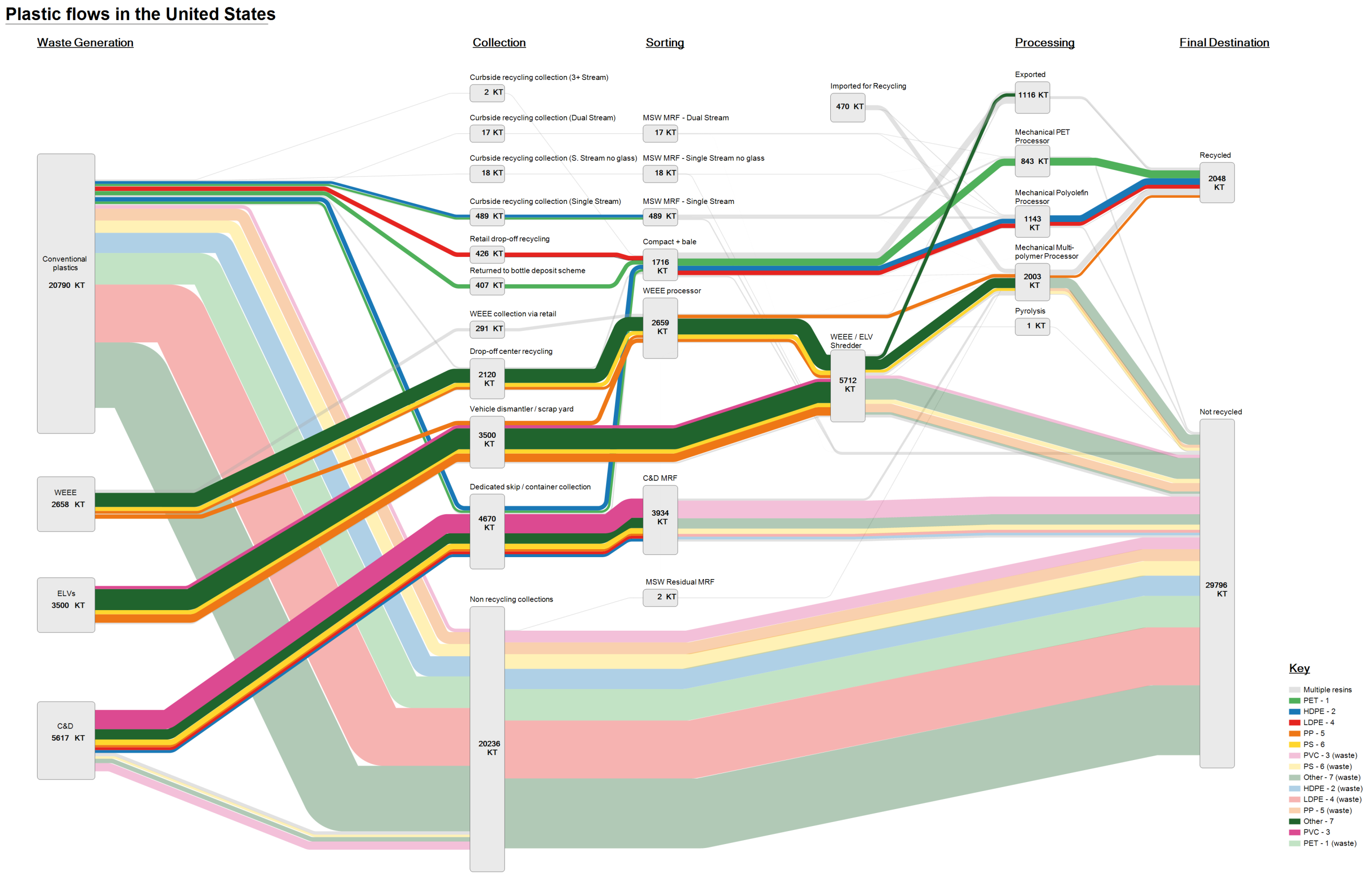
Figure 3. Recycling rates for plastic packaging in the US (2020)



Source: Eunomia Calculations, EPA Data, (Eunomia, 2021), (Stina Inc., 2020), (Sustainable Packaging Coalition, 2021)

Figure 4 shows estimated plastic waste flows in the US in 2021.

Figure 4. Plastic waste flows in the United States in 2021, in kilotonnes (KT)



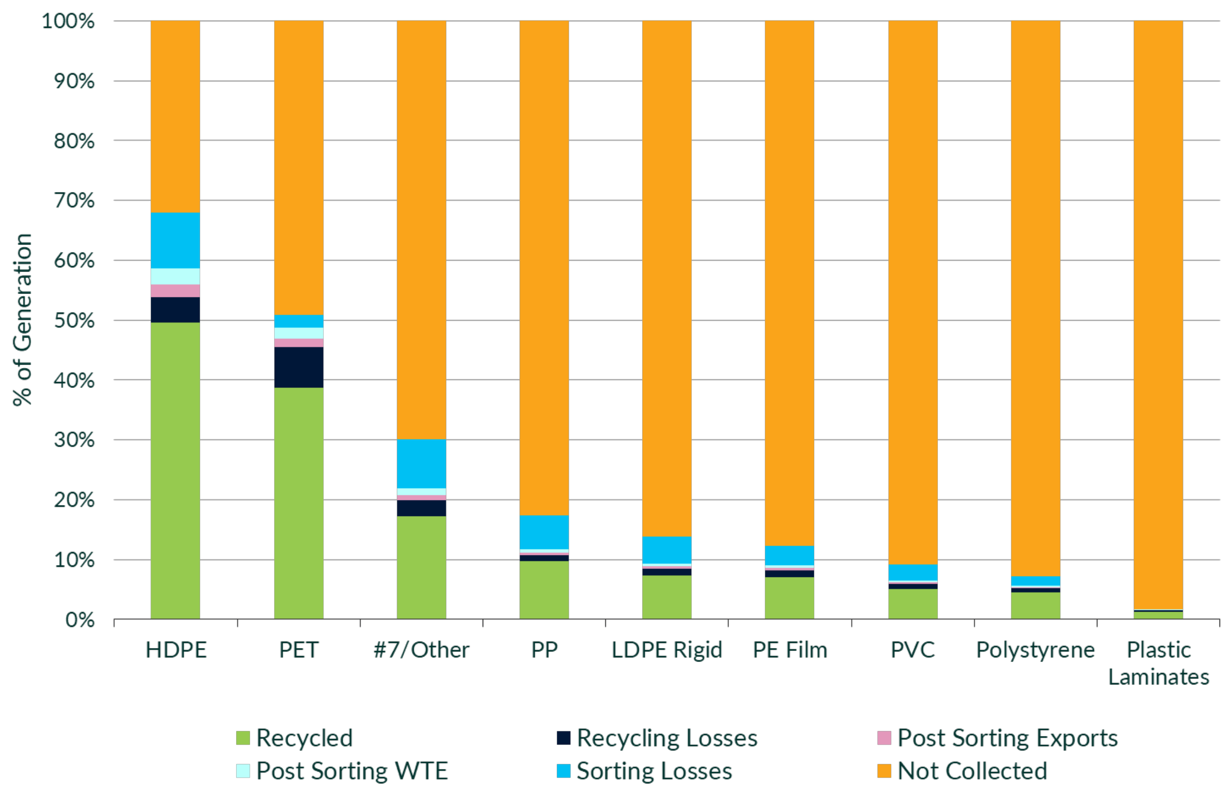
Canada

In 2020, approximately 1.8 million tonnes of plastic packaging waste were generated in Canada, just over 440,000 tonnes of which were collected for recycling in Canada, giving a recycling collection rate of 25%. Collection methods in Canada are similar to those in the US, however, Canada has wider acceptance for plastic materials in curbside collections. For example, PE film is collected at relatively similar levels through curbside as it is through retailers and drop-off center collections, while in the US, there is little to no collection of plastic films through residential curbside collection pathways. Plastic waste that is collected from residential sources via a curbside system must be sorted from other recyclable material at a materials recovery facility (MRF) before it is baled and sent to a recycling facility.

In total, approximately 345,000 tonnes of plastic packaging waste (78% of plastic packaging waste collected in Canada) is recycled in Canada and the US. An additional 13,000 tonnes are exported for recycling outside of North America and an estimated 16,000 tonnes are sent for energy recovery.

Figure 5 shows the end fate of generated plastic waste, by resin. The chart shows the proportion of resins which are reprocessed into new material, as well as where unrecycled material is lost in the waste management chain (e.g., at the sorting, collection, and disposal stages, and subsequently landfilled). HDPE has the highest proportion of tonnage that is recycled, at over 45%. PET is next highest, at just under 40%. The remaining plastics all have reprocessing rates under 20%. Multi-resin films/plastic laminates have the lowest proportion of material reprocessed, and nearly all of the material is not collected for recycling. The overall recycling rate for this group is estimated to be 16%.

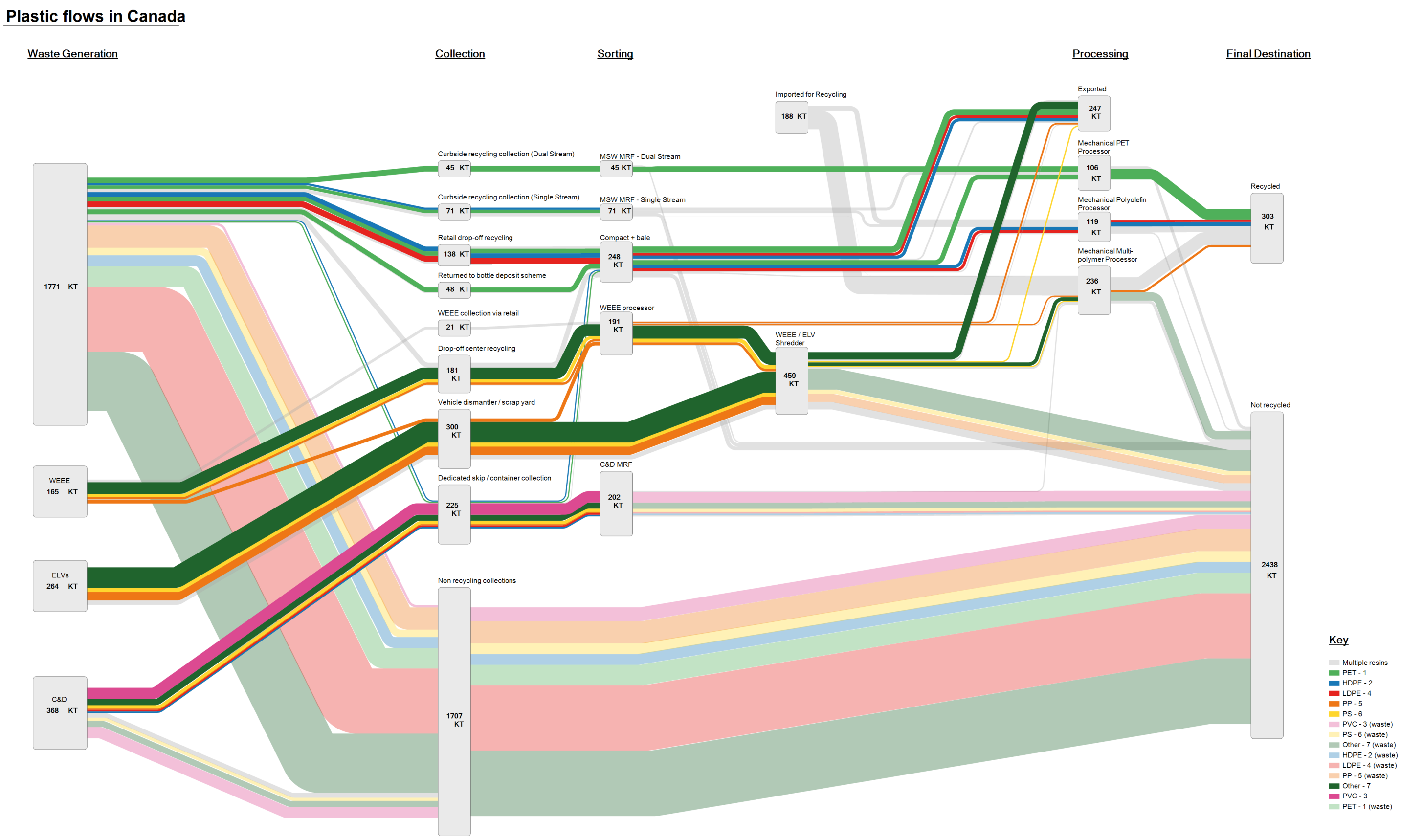
Figure 5. Recycling rates of plastic packaging in Canada (2020)



Source: Eunomia Calculations, StatCan data, 2021, Provincial Stewardship Reports, Stina, 2018, National Postconsumer Recycling Report

Figure 6 shows estimated plastic waste flows in Canada in 2020.

Figure 6. Plastic waste flows in Canada (2020, in kilotonnes (kt))



Summary

In the US in 2021, approximately 21 million tonnes of plastic packaging waste was generated, of which 11% was collected for recycling. In Canada in 2020, approximately 2 million tonnes of plastic packaging waste was generated, of which 25% was collected for recycling. In both the US and Canada, the difference between the collected for recycling and sorted for recycling rate is around 10 to 15% lower, indicating a similar level of sorting efficiency in both countries. Canada is a net importer of plastic waste (with net trade balance of 17 kilotonnes), while the US is a net exporter (-87 kilotonnes).

3.2 Material Flows and Waste Management: Non-Packaging Plastics

The following section gives summaries on plastic waste from electronics, end-of-life (EOL) vehicles, and construction and demolition (C&D) activities in Canada and the US, with the caveat that there is a lack of publicly available, systematized, updated, and validated information on waste management, recovery of recyclable materials, and the various actors involved in all stages of the collection and sorting processes for plastic waste from electronics, vehicles, and the C&D sector.

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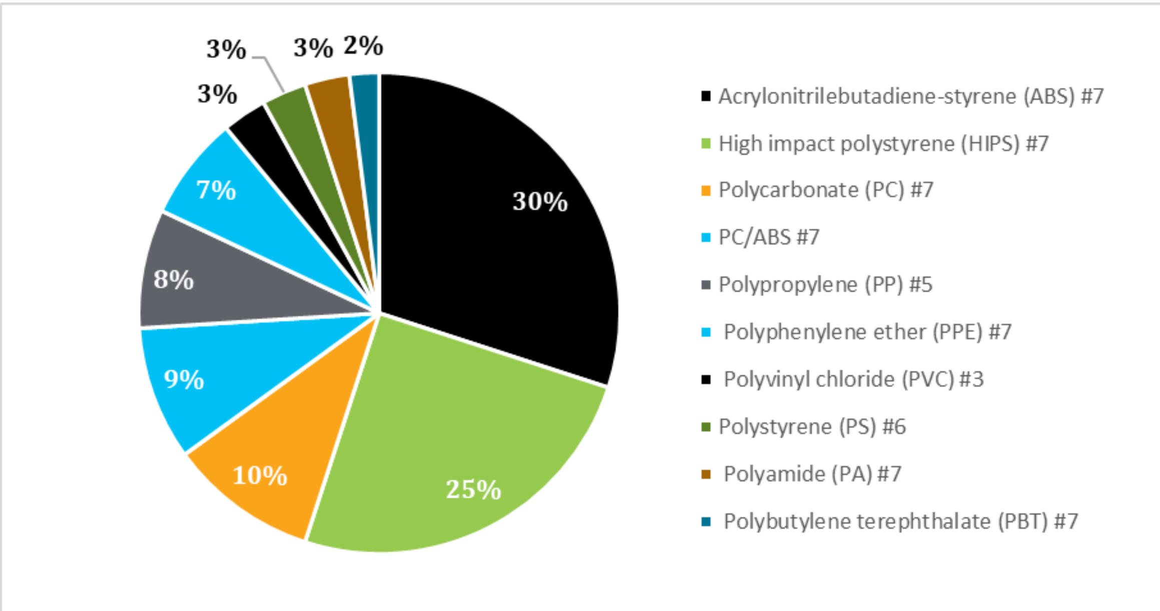
Plastics in Waste Electrical and Electronic Equipment (WEEE)

Waste Electrical and Electronic Equipment (WEEE), also known as electronic waste (e-waste), includes a wide range of products, such as household appliances, computers, televisions, phones, lighting, electronic tools, and much more. Plastics content in WEEE is estimated at 20% to 33%, which varies depending on the type of electronic item (Heller et al., 2020). The composition of plastics within WEEE can vary, but typical breakdown of plastics in electronics (e.g., in outer casings, non-electricity-conducting parts of circuit boards) is depicted in Figure 7.

Figure 7. Typical composition of plastics within WEEE



Source: (Heller et al 2020).

There are several steps involved in the recovery of plastics from WEEE. The heterogeneous combination of plastic types along with the variation in fastener styles, paints, and molded-in metal parts makes WEEE recycling difficult. In addition, mechanical recycling of WEEE is often complicated by the presence of toxics and hazardous substances. As such, much of WEEE is either landfilled or exported to Asia, although the number of countries that are still willing to accept shredded mixed plastic waste from EEE waste recyclers is decreasing. Important to note, depending on the condition of the product, some WEEE can be refurbished or reused, thus extending the product's lifetime and avoiding landfill.

An estimated 2.3 million tonnes of plastic waste from electronics was generated in the US in 2018 and 290,000 tonnes (13%) of that was recycled (US EPA 2022a) (CECED n.d.) (Singh et al., 2018) (Achilias, 2015). An estimated 450,000 tonnes of plastic waste from electronics was generated in Canada in 2019 and 18,000 tonnes (4%) of that was recycled (StatCan, 2023) (CECED, n.d.) (Singh et al., 2018) (Achilias, 2015).

Plastics in End-of-Life Vehicles

In 2020, the automotive sector generated an estimated 3.5 million tonnes of plastic waste in the US and 970,000 tonnes in Canada (Daniels, 2004) (Lowrey, 2011) (European Commission, 2018) (StatCan, 2023). Plastics in automobiles have increased over the past decade, representing an estimated 9-14% of the material weight of passenger vehicles (Heller et al., 2020) (European Commission, 2018). This growth has been due primarily to lightweighting efforts and new applications of polymers such as nylon and polycarbonate to replace metals (Heller et al., 2020). At the same time, the newest cars on the market are entering the next era of automotive technology, with electrification as a key development in the industry. As the number of electric vehicles (EVs) increases, it will have an impact on the automobile recycling industry since EVs have fewer parts overall than internal combustion engine (ICE) vehicles. Additionally, there is an increasing use of plastics within EV batteries themselves, due to their relatively lower cost and lighter weight compared to metallic components (Geiselman, 2022).

Most cars are sold on the secondhand market before being dismantled for recyclable or reusable parts. In fact, the North American used car market is almost 2.5 times larger than the new car market (Frost and Sullivan, 2016).

Currently, it is more cost-effective and less labor-intensive to crush and shred vehicles or appliances for metal recycling rather than to dismantle them for parts, including plastic parts. When end-of-life vehicles are recycled for metals by shredding, via shredder plants, there is a large amount of residue left over. Referred to as automotive shredder residue (ASR), it contains mostly non-metallic materials, like plastics, rubber, wood, paper, textile, leather, or glass. The majority of automotive plastics currently end up in ASR as small pieces mixed with other materials (Heller et al., 2020). Separation and recovery of plastics in ASR is challenging: 39 different types of basic plastics and polymers are commonly used to make cars today, and state-of-the-art separation technologies are very expensive. In the automotive sector, the absence of end markets for the plastics in cars, which are often blends or potentially contaminated by automotive fluids and additives, reduces the incentives for recyclers to explore this avenue (ECCC, 2019).

Plastics in Construction and Demolition

Construction and demolition (C&D) waste includes discarded building materials, packaging and rubble generated during building and structure construction, renovation, and demolition. The C&D sector generated an estimated 5.4 million tonnes of plastic waste in the US in 2018 (US EPA, 2022b) and 1.5 million tonnes in Canada in 2019 (StatCan, 2023). Of this plastic waste, nearly 114,000 tonnes (2%) were recycled in the US and 48,000 tonnes (3%) were recycled in Canada (Napier, 2016) (Light House, 2021).

Estimates indicate that of the building materials waste generated, 10%–15% become waste during construction; the remaining 85%–90% become waste when that part of the building is demolished (Zero Waste Design, n.d.). Several C&D waste composition studies have found roughly 1% (equivalent to 5.4 million tonnes) of C&D waste to be plastic (Napier, 2016) (Cascadia Consulting Group, 2006) (Minnesota Pollution Control Agency, 2020) (Green Seal Environmental Inc., n.d.) (DSWA, 2016). Modern building methods are increasingly using plastics so it is likely the percentage of plastic in future C&D waste will increase (StatCan, 2023). This increased use is largely in the form of PVC and HDPE used for piping, house wraps and siding, trim and window framing, flooring, and plastic-wood composites, as well as rigid polyurethane (PUR) used primarily as insulation.

C&D waste either goes to sorting centers with the remaining or directly to landfill, often to be used as alternate daily cover (NEWMOA, 2006) (Franklin Associates, 1998). Some recovered C&D material can be reused. Organizations recover a wide range of materials from C&D, such as windows, doors, and shingles. which are often made of metals, wood, and asphalt, but often contain plastics in some form.

Separation and recovery of plastics specifically within C&D materials at end-of-life is challenging as building demolition typically produces mixed waste with low fractions of plastics. Further, C&D waste is often contaminated—with paint, adhesives, or fasteners—and potentially toxins (Zero Waste Design, n.d.).

3.3 Key Barriers to Circularity

Table 1 presents a summary of the key barriers to circularity within the plastics value chain for Canada and the US, as identified by sector and value chain stage (production, collection, recycling and reuse). The red, amber, and green coloring (RAG rating) represent the degree of severity of the barrier to plastics circularity, with red representing the greatest barriers and green the least severe barriers[4].

Barriers to circularity are grouped by plastic application: packaging, construction & demolition, automobiles, and electronics. In the second column, the US and Canadian flags are used to indicate which nations the barrier applies to.

Table 1. Barriers to plastics circularity in Canada and the US, according to value chain stage

Sector	Country	RAG rating	Value Chain Stage	Barrier to circularity
Plastic Packaging	 		Production	Limited availability of recycled plastic: Insufficient quality and quantity of recycled plastic to make back into packaging means reliance on virgin plastic is still high. There is greater demand for this material than supply. Insufficient quality and quantity of recyclable material and a volatile market can hinder the recycling industry and limit production of recycled plastic. Issues with collecting clean, recyclable plastics lead to insufficient quality and quantity.

[4] In the full study, the color coding is simply red for the left two columns that outline the challenges and barriers to circularity; green for the right two columns that outline the suggested solutions.

Sector	Country	RAG rating	Value Chain Stage	Barrier to circularity
			Production	Limited use of recycled plastic relative to high use of virgin plastic: Virgin plastics are a relatively inexpensive and lightweight material that is widely used in packaging. There are negative environmental and social impacts associated with the use of virgin material, which is used in increasing quantities for packaging. Recycled content use is limited to a small number of applications and is being used in relatively small quantities.
			Production	Price volatility: Recycled plastic prices are coupled with volatile virgin plastic prices. Price volatility for recycled plastics de-incentivizes their use in manufacturing. Volatile markets make the recycling industry less appealing 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 out compete recycled plastic on price. This in turn can force down the price of secondary plastic material, making the recycling industry less profitable.
			Production	Low recycled content in food grade packaging: There is a challenge for industry to increase the use of recycled content in food grade packaging. There is a lack of infrastructure which can produce food grade recycled resin outside of PET bottles as quality of material feeding into these processors is not pure enough.
			Collection	Low reuse and collection for recycling: In the US and Canada, there is a lack of systems in place that could enable reuse and low recycling collection rates. Some regions, often rural areas, have especially poor access to collection options for plastics recycling, meaning that consumers cannot recycle even if they want to. Across the US and Canada, approximately 20.6 million tonnes of plastic packaging material are disposed of rather than being recycled.
			Collection	Plastics collected for recycling are of low quality due to contamination and how recyclables are collected across the US and Canada. Single-stream collection for households means that plastics are mixed with other recyclables (glass, paper) or with general waste (organic, non-recyclable). These contaminants must be sorted out for plastic to be recycled, which requires investment in sorting infrastructure and still leads to losses if contaminants cannot fully be separated. Additionally, inconsistent recycling requirements across different jurisdictions have resulted in consumer confusion regarding what items are recyclable. This inconsistency also poses challenges for creating uniform messaging or labeling, either on product packaging or waste containers, to educate consumers about correct disposal options and recycling practices.

Sector	Country	RAG rating	Value Chain Stage	Barrier to circularity
			Recycling	Limited data availability: There is limited availability of data concerning end-of-life treatment of plastics and the processing capacities of facilities which means that we lack detailed insight into tonnages of different materials in circulation, either entering the waste stream or escaping to the environment, and about flows of material within waste streams, including how they are ultimately processed. Without this information, knowing how and where to make improvements is challenging.
			Recycling	There is minimal recycling of multi-material flexible plastics and currently a nearly negligible recycling rate of multi-material flexible plastics. There is a severe lack of infrastructure to sort and process multi-material flexibles, specifically infrastructure able to process these materials without incurring contamination problems.
			Recycling	Unreliable comparisons across jurisdictions: Reliable data on how recycling rates compare across jurisdictions are lacking, and there is no consistent methodology for measuring recycling rates or recycled content across the US and Canada, which would be crucial for monitoring progress toward future circularity.
			Recycling	Relatively low beverage container recycling rate: The recycling rate for beverage containers is low, relative to those of other countries with DRS programs. DRS is not implemented in 40 of the 50 states in the US, and DRS programs in those ten US states are not consistent and do not cover all beverage containers.
Construction & Demolition			Production	Increasing virgin plastic use in construction with limited consideration of end-of-life reuse or recycling: Fossil-fuel plastics are increasingly being used as construction materials since they are a relatively inexpensive and lightweight material. However, there are negative environmental and social impacts associated with the use of virgin material, which is used in increasing quantities compared to recycled content plastics.
			Reuse	There is low to minimal reuse of Construction & Demolition (C&D) plastic waste: Relative to other types of plastic waste, there is difficulty separating the plastic in C&D waste from other mixed materials. There are also challenges for storing used building materials over long periods of time due to their large size. It is difficult to access used materials from other construction projects due to size, project timelines, and a lack of awareness about what materials are available. Lastly, there are potential concerns about liability or material condition in relation to structural integrity which increase friction to reuse plastic materials in construction.

Sector	Country	RAG rating	Value Chain Stage	Barrier to circularity
			Recycling	There is also a low recycling rate of plastics from C&D waste compared to other plastic waste categories. The plastic in C&D waste is often difficult to separate from mixed materials, as stated above. Additionally, such plastic is of low value compared to other materials, such as metals. Further reducing their value, some plastics used in construction release dioxins or will have deteriorated from use by end of life.
End of Life Vehicles			Production	There is increasing use of virgin fossil fuel plastics in automotive sector. Substituting plastics for other, heavier materials such as metal, can reduce the weight of vehicles, thus improving fuel efficiency and reducing emissions.
			Recycling	There is a low recycling rate of plastics in automotive sector: It is difficult to separate some of the plastic within vehicles from mixed materials. Not all vehicles are deconstructed before being shredded, as it is often more cost-effective and less labor-intensive to crush and shred vehicles rather than to dismantle parts. Overall, there is minimal sorting. Plastic in vehicules mostly becomes automotive shredder residue (ASR).
Waste Electrical and Electronic Equipment			Production	There is increasing use of virgin fossil fuel plastics in electronics because they are a relatively inexpensive and lightweight material.
			Production	Consumption frequency of select electronics is increasing: some are not designed for longevity, instead being designed to be replaced every 2-3 years. For some products, such as cell phones, annual upgrades are incentivized (e.g., discounts, promos, etc.) by producers. Additionally, there is limited accessibility for repair due to proprietary parts, tools, etc. that limit who or what organizations can repair.
			Recycling & Reuse	It is difficult to separate parts, including plastics, that would enable recycling for many electronics. Many electronics are not designed to enable easy/efficient dismantling, sorting, and recycling or reuse of parts.

4 Recommendations to Increase Circularity

A range of policy approaches and waste management practices are available to help overcome the barriers to plastics circularity in Canada and the US listed above. While some of these serve as solutions to specific problems along the value chain, many have the potential to be leveraged to address multiple issues. Furthermore, as the stages of the value chain do not operate in isolation but rather influence each other, often implementing measures at one point will result in benefits downstream. The key recommendations arising from this milestone study are outlined below.

4.1 Packaging

Research & Investment into Reuse

Redesigning plastic products for reuse and refill plays an important role in the circular economy. Reuse systems extend a product's lifetime, keeping it in use for a longer period and avoiding the emissions, waste, and costs associated with the extraction of new, virgin materials or the processing required to recycle materials. Some of the initial areas governments could invest in to encourage reuse are listed below:

- Carry out a study to identify in which locations and in what contexts (e.g., food and beverage, online shopping delivery packaging) reuse and refill is being used and/or trialed. Where suitable, set up public-private sector partnerships to invest in reuse infrastructure (e.g., washing facilities, collection systems), zero waste packaging shops, and pilot projects.
- Identify packaging types that would benefit from grant programs for reuse/refill projects. Identify packaging types for which bans or taxes would be appropriate measures (making sure to consider the impact of substitute materials).
- Carry out a study to review and evaluate existing reuse standards. Then, following this, identify needs and recommend or develop standards where suitable.

Research & Investment into Recycling

Currently, plastic waste in Canada and the US is processed mainly using mechanical recycling technologies which focus primarily on recovering rigid packaging (like bottles); its use for flexible packaging and films is less common. Advanced recycling technologies are expanding to increase the range of plastics that are recyclable at scale. Some potential areas for further investment to expand plastic packaging recycling are listed below:

- Consider investment and pilot projects to accelerate technology for chemical recycling to address plastic waste not suited for mechanical recycling.
- Invest in technology R&D and pilot facilities that can sort and process multi-material flexibles.
- Encourage federal leadership to define chemical recycling in order to standardize the industry.
- Carry out a study into which multi-material flexibles are most problematic and what alternatives could be used if policies, such as a ban, were implemented to reduce their use.
- Encourage investment and pilot studies in food-grade recycling technologies. Governments can work with industry to align on requirements needed for food grade recycled content.

Extended producer responsibility (EPR)

Extended producer responsibility (EPR) is an environmental policy approach in which producers bear the financial responsibility for managing the packaging they place on the market at end-of-life. EPR is in place for plastic packaging in four US states and seven Canadian provinces. It can be leveraged to promote circularity in a number of ways, including:

- Introducing requirements for producers to fund specific types of collection services where collection rates are currently low. For example, in Canadian provinces with full EPR programs, producer responsibility organizations (PROs) could be directed to set service rate targets for multi-family residential buildings. More generally speaking, EPR could be used to set collection and recycling targets for both residential and industrial, commercial, and institutional (ICI) collections.

- Shifting the financial burden of collection from municipalities onto producers, thereby helping to financially insulate collection services from market fluctuations.
- Modulating EPR product fees to incentivize the inclusion of recycled content by providing a bonus to those who integrate a given percentage of recycled plastics. Fee modulation could also be used to incentivize design for recycling, for example, to stimulate solutions for overcoming the challenges associated with recycling certain types of packaging, such as multi material layered flexible plastics.
- Using funds from EPR to finance investments in recycling infrastructure, such as upgrading MRFs for better sorting of flexible films and removal of contamination.
- Using funds from EPR to finance education and outreach to improve consumer participation in collection schemes, improving both collection rates and quality of material collected (due to reduced contamination, thanks to improved recycling behavior).
- Requiring producers to report sales and performance data to allow for better tracing of packaging placed on market and material flows. Increased data availability allows for easier tracking of progress toward circularity and comparison across jurisdictions.
- Setting targets for recycled content and for reduction in virgin, fossil-based plastics in packaging. This could be furthered by supporting industry standardization of recyclate specifications (e.g., those currently being developed by the Alliance to End Plastic Waste) and liaising with CEN and CENELEC on the standards that they are revising and developing in Europe to support the European Strategy for Plastics in the Circular Economy. Virgin fossil fuel plastics could be further disincentivized via taxes; however, before review and evaluation of plastic taxes in other jurisdictions it would be crucial to first assess suitability of a similar tax in Canada and the US.
- Integrating reuse requirements and funding for reuse projects and infrastructure into EPR. Reuse can be incentivized via many avenues, often working in tandem to incentivize reuse and disincentivize single-use alternatives.

Deposit-refund systems (DRS)

A deposit-refund system (DRS)—also called a 'container deposit system' 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 the product to a designated location for reuse and/or recycling. Passing DRS in jurisdictions in which these are not currently in place can help to increase the volume of plastic bottles collected domestically and thereby improve high quality recycling feedstock availability. Incorporating reuse targets can help incentivize the development of reuse infrastructure and increase reuse rates in the jurisdiction.

DRS also typically leads to better data due to increased tracking of products placed on the market. Aligning DRS across jurisdictions (e.g., ensuring they include the same fundamental material list) can help to increase standardization of waste management and reduce consumer confusion.

Recycled Content Targets

Recycled content targets could help to reorientate the plastics value chain away from its historical dependance on virgin plastics, toward using more recycled material. They would provide a clear market signal for recyclers by creating stable demand and prices for recycled plastic. They can also be used to drive innovation to overcome the challenges associated with some difficult to recycle plastics, such as flexible films. As such, a first step would be to assess to what extent recycled content could be applied to different packaging materials, then develop ambitious but feasible targets and legislate for minimum recycled content requirements to increase demand for recycled plastics.

In practice, government at both the national/federal and state/province/territory levels could update or pass new legislation that would require plastic packaging and products to have a certain percentage of recycled content. Any percentage targets set could then increase with time to allow industry to gradually scale up recycled plastics use. This could be strengthened by supporting industry standardization of recyclate specifications (e.g., those currently being developed by the Alliance to End Plastic Waste) and liaising with CEN and CENELEC on the standards they are revising and developing in Europe to support the European Strategy for Plastics in the Circular Economy. Additionally, Canada and the US could coordinate to develop a regional standard to measure recycled content to enable cross-jurisdictional alignment on recycled content measurement. Further, jurisdictions should begin collaborative discussions around calculation methods for recycling rates to align on that front as well.

There are other kinds of targets, beyond recycled content goals, that can help move the plastic packaging industry towards circularity. This includes targets for plastic source reduction, reuse for single-use plastic packaging, and reduction in virgin, fossil-based plastics in packaging. Almost all targets could be part of an EPR or introduced as separate policies, as suits the legislative context.

Consistent Collection Services

To address the consumer confusion resulting from a lack of consistency across different collection services—which results in lower service participation and higher contamination—policy makers should seek to harmonize collections. The potential solutions for achieving this include:

- Harmonizing/standardizing the materials that can be recycled regionally, in a jurisdiction, and/or nationally.
- Implementing country-wide labeling requirements for recyclability, including consistent color for containers/bins for recycling, based on industry best practices.

Design Requirements

Policies to optimize packaging design can reduce plastic waste generation and improve its recyclability and reusability. Many of these requirements could be integrated into larger policy mechanisms, such as EPR. Some examples include:

- Require reduction of unnecessary headspace in packaging (i.e., reduce empty space within packaging) and right-sizing for all packaging.

- Require removal of plastic overwraps (i.e., the plastic film that covers products like produce, meat, or packs of soft drinks for example) by requiring them to be used only when "necessary" and down-gauged wherever possible.
- Set design requirements for flexible films that enable easier sorting and recycling (e.g., mono-material flexibles).
- Support and increase grants for research and design into improved packaging for recyclability.

4.2 Non-Packaging Plastics

Construction and Demolition (C&D) Waste

There is a low recycling and reuse of C&D plastic waste largely because it is difficult to separate the plastic in C&D waste from other mixed materials. Options to encourage reuse and design for disassembly include:

- R&D into construction methods that allow for easy EOL sorting, including for plastic components. Engage value chain stakeholders in collaboration to understand use needs and EOL options prior to engaging in retail competition.
- Set requirements for on-site source separation of materials, which reduces sorting loss rates and increases the quality of the waste stream: i.e., less material is lost to contamination.
- Facilitate connection/accessibility to reusable plastic materials in order to encourage adaptive reuse. This might include offering grants for local building resource reuse centers that store and sell used building materials to allow for storage and reuse.

Other barriers to the reuse of plastics in construction are potential concerns about liability or condition of materials in relation to structural integrity. To overcome this, create a verification standard/system that would provide industry with confidence in the plastic material intended for reuse. Clarify: (1) material testing standards for reuse, and (2) liability around the use of secondhand materials in construction.

Plastics are relatively inexpensive and lightweight materials that are increasingly being used in construction. To reduce the use of virgin, fossil-fuel plastics in construction, the use of recycled content and sustainably sourced, recyclable, bio-based, non-biodegradable replacements need to be increased. This can be supported by implementing minimum recycled-content requirements to increase demand for recycled plastics.

End-of-Life Vehicles

Using plastics to replace other, heavier materials such as metal, can reduce production costs and decrease the weight of vehicles, thus improving fuel efficiency and reducing emissions. As a result, there is an increasing use of plastics in the automotive sector and steps can be taken to encourage the use of recycled content and sustainably sourced, recyclable, bio-based, non-biodegradable plastics instead of virgin fossil fuel-based plastics. These might include setting recycled content requirements for new vehicles, financial incentives (e.g., tax breaks) for auto designs that meet recycled content minimums, or grants for R&D into design using recycled plastics in automobile manufacturing.

The low recycling rate of plastics in the automotive sector is largely due to difficulties separating plastic parts. Governments could offer grants or financial incentives for auto designs that incorporate design for deconstruction and EOL considerations. Additional research is needed to investigate how to improve recovery of plastics from automotive shredder residue (ASR).

Waste Electrical and Electronic Equipment

Plastics are a relatively inexpensive and lightweight material and are thus used in many kinds of electronics. Thus governments need to support the use of recycled content and sustainably sourced, recyclable, bio-based, non-biodegradable plastics instead of virgin fossil fuel-based plastics within the industry. This might include setting recycled content requirements for plastics used within electronics, financial incentives for electronics that meet recycled content minimums, or grants for incorporating R&D into design, using recycled and bio-based plastics in electronics.

Increased frequency of consumption and obsolescence of select electronics worsens the problem of waste. Incentives to discourage planned obsolescence and encourage longer product lifetimes, enabling reuse and refurbishment, are crucial within the electronics sector. Governments can also implement right-to-repair legislation. This would establish that consumers and independent repair providers have a right to obtain manuals, diagrams, diagnostics, and parts from original equipment manufacturers in order to repair their devices.

5 Conclusion

The findings from these milestone studies of paper, plastics, and bioplastics waste will provide key input for defining and developing appropriate pilot projects in Phase II of the Commission for Environmental Cooperation's Operational Plan 2021 project, "Transforming Recycling and Solid Waste Management in North America."

Bibliography

Achilias, D. (2015). Chemical and thermochemical recycling of polymers from waste electrical and electronic equipment. Recycling materials based on environmentally friendly techniques , 306-315.

Cascadia Consulting Group. (2006). Targeted Statewide Waste Characterization Study: Detailed Characterization of Construction and Demolition Waste. California Environmental Protection Group. Retrieved from https://www2.calrecycle.ca.gov/WasteCharacterization/PubExtracts/34106007/Tables.pdf

CECED. (n.d.). Material Flows of the Material Flows of the. Retrieved from http://www.materialflows.eu/assets/Material_Flows_of_the_HA_Industry_LR.pdf

Daniels, E. (2004). Sustainable end-of-life vehicle recycling: R&D collaboration between industry and the US DOE. JOM 56, 28-32. Retrieved from https://link.springer.com/article/10.1007/s11837-004-0177-4

DSWA. (2016). Delaware Solid Waste Authority Statewide Waste Characterizertion Study, FY 2016. Final Report. Retrieved from https://dswa.com/wp-content/uploads/2017/02/Final-Report-DSWA-Waste-Characterization-FY-2016-January-2017.pdf

Environment and Climate Change Canada. (2019). Economic Study of the Canadian Plastic Industry, Markets and Waste. ECCC. Retrieved from https://publications.gc.ca/collections/collection_2019/eccc/En4-366-1-2019-eng.pdf

Eunomia. (2021). The 50 States of Recycling: A State-by-State Assessment of Containers and Packaging Recycling Rates. Eunomia. Retrieved from https://www.eunomia.co.uk/reports-tools/the-50-states-of-recycling-a-state-by-state-assessment-of-containers-and-packaging-recycling-rates/

European Commission. (2018). Plastics: Reuse, recycling and marine litter. Final Report. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/3cdca2d1-c5f2-11e8-9424-01aa75ed71a1/language-en

Franklin Associates. (1998). Characterization of Building-Related Construction and Demolition Debris in the United Stated. US EPA. Retrieved from https://www.epa.gov/sites/default/files/2016-03/documents/charact_bulding_related_cd.pdf

Frost & Sullivan. (2016, July 13). Used Car Market in North America 2016–2022. Retrieved April 11, 2023, from https://store.frost.com/used-car-market-in-north-america-2016-2022.html

Geiselman, B. (2022, February 16). Plastics trim EV batteries' weight, boost safety. Retrieved July 7, 2023, from https://www.plasticsmachinerymanufacturing.com/injection-molding/article/21254768/plastics-trim-ev-batteries-weight-boost-safety

Green Seal Environmental Inc. (n.d.). Construction and Demolition Waste Characterization and Market Analysis. The Department of Energy and Environmental Protection. Retrieved from https://portal.ct.gov/-/media/DEEP/waste_management_and_disposal/Solid_Waste_Management_Plan/CMMSFinal2016ConstructionAndDemolitionWasteCharacterizationStudyPDF.pdf

Heller et al. (2020). Plastics in the US: toward a material flow characterization of production, markets and end of life. Environmental Research Letters. Retrieved from https://iopscience.iop.org/article/10.1088/1748-9326/ab9e1e

Light House. (2021). Residential Construction Waste Analysis. BC Housing. Retrieved from https://www.light-house.org/wp-content/uploads/2021/05/Residential-Construction-Waste-Analysis-May-27-2021.pdf

Lowrey, A. (2011, June 27). Your Big Car Is Killing Me. Retrieved April 11, 2023, from https://slate.com/business/2011/06/american-cars-are-getting-heavier-and-heavier-is-that-dangerous.html#:~:text=The%20average%20new%20car%20weighed,but%204%2C009%20pounds%20in%202010

Minnesota Pollution Control Agency. (2020). Construction and Demolition Materials Composition Study. Study. Retrieved from https://www.pca.state.mn.us/sites/default/files/w-sw5-55.pdf

Napier, T. (2016). Construction Waste Management. 17: October. Retrieved from https://www.wbdg.org/resources/construction-waste-management

NEWMOA. (2006). CD Report. Retrieved from https://www.newmoa.org/solidwaste/CDReport2006DataFinalJune302009.pdf

Singh, N., Duan, H., Yin, F., Song, Q., & Li, J. (2018). Characterizing the Materials Composition and Recovery Potential from Waste Mobile Phones: A Comparative Evaluation of Cellular and Smart Phones. ACS Sustainable Chemistry & Engineering. doi:https://doi.org/10.1021/acssuschemeng.8b02516

Statistics Canada. (2023, March 9). Pilot physical flow account for plastic material, by product category. Retrieved April 11, 2023, from https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810015001

Stina Inc. (2020). 2020 U.S. Post-consumer Plastic Recycling Data Report. APR. Retrieved from https://circularityinaction.com/2020PlasticRecyclingData

Sustainable Packaging Coalition. (2021). Centralized Study on Availability of Recycling. Retrieved from https://sustainablepackaging.org/wp-content/uploads/2022/03/UPDATED-2020-21-Centralized-Study-on-Availability-of-Recycling-SPC-3-2022.pdf

US EPA. (2022, December 3). Construction and Demolition Debris: Material-Specific Data. Retrieved April 11, 2023, from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/construction-and-demolition-debris-material

US EPA. (2022, December 3). Facts and Figures about Materials, Waste and Recycling. Retrieved April 11, 2023, from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/durable-goods-product-specific-data#Electronics

Zero Waste Design. (n.d.). C&D Activities and Waste Stream. Retrieved April 11, 2023, from https://www.zerowastedesign.org/02-building-design/e-construction-and-demolition-waste-context/

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