Economic Study of the

CANADIAN PLASTIC INDUSTRY, MARKETS AND WASTE

Summary Report to Environment and Climate Change Canada

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada

Cat. No.: En4-366/1-2019E-PDF
ISBN: 978-0-660-30447-2

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This project was overseen, funded and coordinated by Environment and Climate Change Canada (ECCC).

Disclaimer

The assumptions and parameters used in the plastics waste management value chain modelling are based on a review of literature, industry reports and national statistics, as well as consultations completed with industry stakeholders. The Canadian Plastics Industry Association (CPIA) and the Chemistry Industry Association of Canada (CIAC) were consulted to ensure representation of the plastic resin industry. Stewardship organizations such as the Canadian Stewardship Services Alliances (CSSA) and Éco Entreprises Québec were consulted to gather information on residential packaging plastic waste collection and associated costs. Several provincial ministries, government agencies such as RECYC-QUÉBEC, and industry associations were consulted to inform the current state of recycling within their sector or region. To the extent possible, information gathered was cross-checked with additional sources of information such as data from Statistics Canada Waste Management Information Survey (WMIS) and reports such as the 2016 Post-consumer Plastics Recycling in Canada report from More Recycling (More Recycling, 2018)*. For greenhouse gas emissions life cycle data from previous studies conducted in Europe and from recognized lifecycle databases has been leveraged to provide greenhouse gas emissions factors for key steps of the value chain.*

Given the national scope of the study, the complexities of interactions between sector- and resin-level analysis, and the limited timespan within which this study was conducted, limitations and uncertainties remain in the results presented in these reports. First, the model developed by the authors to build the 2016 baseline and 2030 scenario projections does not reflect the specificities of all products containing plastics, given that a key source of information, the Supply and Use Table from Statistics Canada, was built using a limited number of product categories (286 product categories within the Canadian economy). Second, the model does not reflect all possible feedback loops (e.g. re-use/repair impact on actual new product demand). Third, imports and exports of sorted plastic wastes were excluded from the models used for the 2016 baseline (as it was difficult to allocate imports and exports to specific resins or sectors given available statistical data) and for the 2030 projections (as it was difficult to forecast import/export evolution). Finally, the recycling rates presented in this study are measured in relation to the output of recyclers in Canada, after factoring in all intermediate losses (sorting and reprocessing).

Consequently, numerical values appearing in this report represent average value estimates and should only be interpreted as such. The actual values of a specific product within a given product category might be different (higher or lower) and therefore no specific product or sector conclusion should be made without consideration of this limitation and undertaking additional research procedures.

Minor discrepancies may occur between stated totals and the sums of component items, as totals are calculated using component item values prior to rounding. Minor discrepancies between summary tables and figures presented may occur, in particular between task reports as their supporting methodology differed, in line with the overall goal of their respective tasks. General alignment has, however, been confirmed, with a few exceptions at intermediary steps of the recycling value chain. Assumptions and calculations have been made as transparent as possible to enable the future refinement of the model once new specific data points and research become available.

Executive summary

A unique view on plastics in Canada

ECCC commissioned this Economic Study of the Canadian Plastic Industry, Markets and Waste in July 2018. The scope of the study, encompassing most plastics types used across all key sectors, is a unique attempt to shed light on the entire plastics value chain in Canada, from raw material production and products manufacturing to use and end-of-life.

The authors leveraged a wide selection of primary and secondary sources to complete the four task reports that constitute the backbone of the results presented in this summary report (Deloitte, 2019a) (Deloitte, 2019b) (Deloitte, 2019c) (Deloitte, 2019d). In addition to national statistics, the authors reviewed over 220 documents and industry reports and conducted more than 130 interviews.

This report first presents an overview of the plastics value chain beginning with raw material production (virgin plastics resins) before moving into plastics products manufacturing and their end-use in key sectors, and concluding with an analysis of their end-of-life management. The report then describes 2030 scenarios, highlighting potential paths for the plastics value chain, in particular relating to end-of-life performance. The report then presents a high-level economic, environmental and social impact assessment to discuss the scenarios and their feasibility. Finally, the report introduces a review of policy measures that could be implemented to support the growth of the secondary plastics markets in Canada.

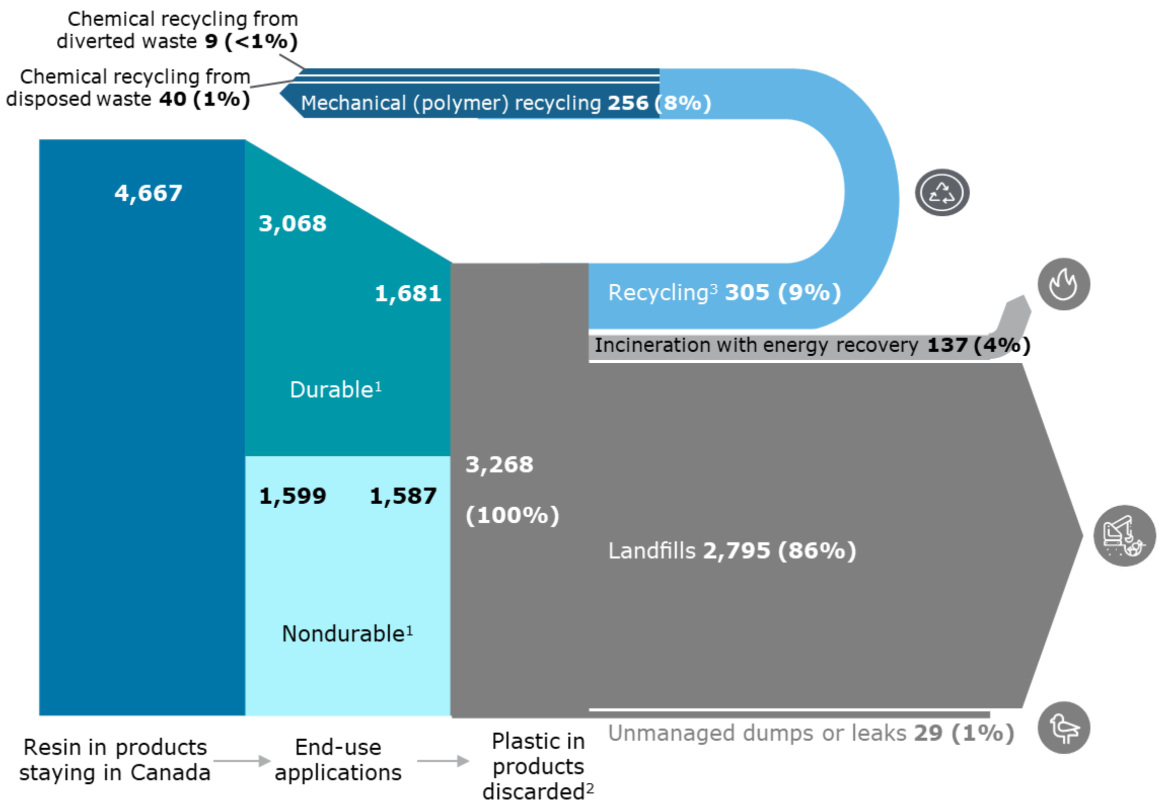
Plastics resins and products: CA$35 billion in sales in Canada

With total sales estimated at CA$35 billion, plastic resin (CA$10 billion) and plastic product (CA$25 billion) manufacturing in Canada accounts for over five percent of the sales in the Canadian manufacturing sector, and employs 93,000 people across 1,932 establishments. Present in almost every modern product, global demand and production of plastics is growing. In Canada, plastic products are in demand in most sectors of the economy, with approximately 4,667 kilotonnes (kt) of plastics introduced to the domestic market on an annual basis (more than 125 kg per capita). Three categories (packaging, construction and automotive) show a particular appetite for plastic, accounting for 69 percent of plastic end-use.

Canada's CA$7.8 billion lost opportunity: 87 percent of plastics waste ends up in landfills or the environment

The Canadian plastics economy is mostly linear, with an estimated nine percent of plastic waste recycled, four percent incinerated with energy recovery, 86 percent landfilled, and one percent leaked into the environment in 2016 (Figure 1). Thus, plastics material not recovered (i.e., 2,824kt of resins sent to landfill or leaked into the environment) represented a lost opportunity of CA$7.8 billion for Canada in 2016, based on the value of virgin resin material.

Figure 1: Canadian resin flows in thousands of tonnes per annum, 2016



[1] Durable applications with an average lifetime >1 year will end up as waste only in later years; given market growth and increase share of plastics in durable applications (e.g., construction, cars) plastics waste generated today is less than what is being put in the market that same year. On the contrary nondurable applications go almost straight to waste.

[2] 1,587 thousand metric tons of mixed plastic waste from nondurable applications plus 1,681 thousand metric tons of mixed plastic waste from production in previous years.

[3] Output recycling rate, after taking into account process losses.

The main generating sectors for plastic waste are packaging (43 percent of total plastic waste), automotive (9 percent), textiles (7 percent), and electrical and electronic equipment (EEE 7 percent). The construction sector, while an important end-use market (accounting for 26 percent of plastic put on the market), is not yet a large plastic waste generator (5 percent), given the fairly recent incorporation of plastics in construction (in the 1980s and 90s) that remains 'stocked' in houses and buildings; this situation could change in future years with construction renewal. Under a business as usual situation, the linear profile of the Canadian plastics economy is not going to improve given forecasted trends in waste streams and economic drivers.

By 2030, it is estimated that Canada's lost opportunity related to unrecovered plastics could rise to CA$11.1 billion, under a business as usual scenario following the same end uses and value recovery performance as the current baseline (Figure 1).

Given current market prices, structures, business models and the low cost of disposal, there is limited direct economic incentive for plastics recycling and value recovery in Canada

Domestically recycled "secondary" plastics output accounted for approximately CA$350 million in sales in Canada in 2016. In comparison with the sales of its primary resin competitor, it is 30 times smaller. The recycling industry focuses on polyethylene terephthalate (PET), high-density polyethylene (HDPE) and polypropylene (PP) and is predominantly located in large end-markets providing easier access to plastic waste feedstock, such as in Ontario, Quebec and British Columbia.

The Canadian virgin "primary" resin domestic output accounts for CA$10 billion annually and is driven by global oil prices and investment in large scale industrial facilities in locations allowing access to advantaged petrochemical feedstock, such as in Alberta or Ontario. Canadian virgin resin production focuses on high-volume resins such as polyethylene. The virgin resin industry has a very high international trade exposure, with 77 percent of its output exported, and 71 percent of the domestic resin demand fulfilled through imports. The United States (US) is the main trading partner, accounting for more than 80 percent of import and export of the industry.

Primary and secondary plastics compete against each other in the same market, based on price and quality of the resins. This competition is difficult for the recycling industry, which struggles with quality due to uneven feedstock composition, and on prices. Secondary plastics producers enjoy lower upfront investment than their virgin competitors do; however, during periods of low oil prices which bring downward prices for virgin resins, secondary resins producers are more exposed than their virgin counterparts as their cost structure is more labor-intensive. This is one reason why many secondary plastics producers ceased operations in 2016 in North America, as oil prices were low.

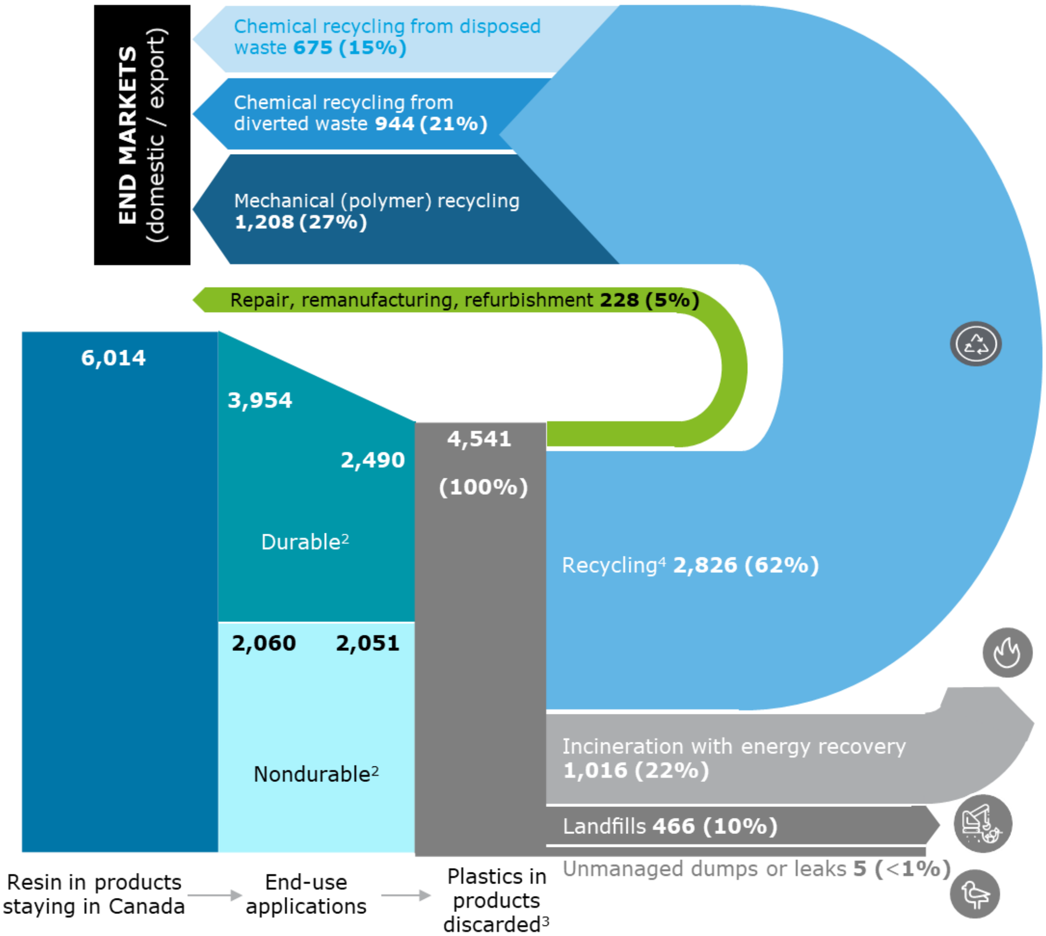
Overall, value recovery options are only as strong as their weakest link in the value chain and face competition from low-cost alternatives such as landfilling. Key barriers to the recovery of plastics include a combination of factors, such as: low diversion rates (only 25 percent of all plastics discarded are collected for diversion); process losses in the sorting (e.g., shredded residues containing plastic sent to landfill) and reprocessing stages; and the near-absence of high volume recovery options for hard-to-recycle plastics (e.g., plastics waste coming from the white goods, EEE or automotive sectors).

Mechanical recycling, which is currently the dominant value recovery option, only reprocessed eight percent of total plastics waste in Canada in 2016. Economic incentives are still limited, coupled with other factors including collection and processing costs, poor product design, and low participation in recycling programs. Several chemical recycling technologies exist that could allow the market to process monomers, petrochemical feedstock or fuels; however, these technologies require further investment to confirm their full-scale commercial viability in the Canadian plastic waste context.

A zero plastic waste economy would deliver significant benefits to Canada

An ambitious 2030 scenario was developed to model the potential costs and benefits of achieving zero plastic waste (2030_{T90}). This scenario used a 90% landfill diversion rate as a proxy for zero plastic waste and assumed that: i) plastics production and end use applications increased but followed the same patterns as in 2016, ii) mechanical recycling was quadrupled from its business as usual level; iii) chemical recycling was significantly scaled up, taking into account readiness levels and associated learning curves and iv) energy from waste was leveraged to deal with the remaining volumes and hard-to-recycle plastics.

Figure 2: Canadian resin flows in thousands of tonnes per annum, 2030_{T90} scenario1



[1] Scenario based on a multi-stakeholder push to boost recycling, including investment in new facilities, regulatory measures to encourage recycling, significant progress on technologies and favorable end-markets demand.

[2] Durable applications with an average lifetime >1 year will end up as waste only in later years; given market growth and increase share of plastics in durable applications (e.g., construction, cars) plastics waste generated today is less than what is being put in the market that same year. On the contrary nondurable applications go almost straight to waste.

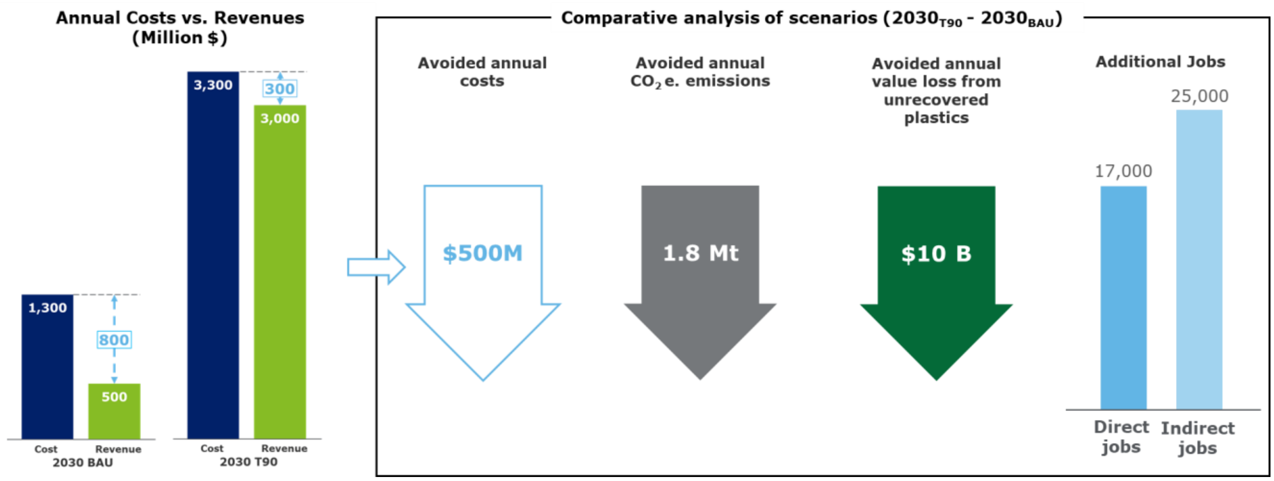
[3] 2,051 thousand metric tons of mixed plastic waste from nondurable applications plus 2,490 thousand metric tons of mixed plastic waste from production in previous years.

[4] Output recycling rate, after taking into account process losses

This scenario is not a prediction or a recommendation: it is an illustration of what zero plastic waste could look like given current product designs and emerging value recovery technologies. Changes in plastic production and design would open the door to higher value recycling and recovery options.

However, even without such changes, a preliminary comparative analysis (Figure 3) shows that 2030_{T90} would deliver significant benefits to Canada in comparison to business as usual (2030_{BAU}): CA$500 million of annual costs avoided, 42,000 direct and indirect jobs created, and annual greenhouse gas emissions savings of 1.8Mt of CO_2 eq.

Figure 3: Comparative analysis of scenarios



This analysis indicates that zero plastic waste cannot be achieved without concurrent, strategic interventions by government, industry stakeholders and the public across each stage of the plastic lifecycle and targeted at sectors

Business-as-usual or incremental changes are not an option to reach the target and the modelled 90 percent plastic waste recovery. Achieving 90 percent plastic waste recovery will require significant investment to diversify and expand the capacity of current value recovery options including mechanical recycling as the most mature technology, but also chemical recycling and waste-to-energy. It will also require significant improvements to current plastic waste diversion rates, which vary depending on sector specific approaches. An international benchmark demonstrated the need for a systemic approach, acting in several areas simultaneously, as no single public or private sector action can shift the system.

Five sets of interventions (e.g. policies, measures and calls-to-action) were identified as having been effective in other jurisdictions and could be used to achieve zero plastic waste in Canada:

Set 1: Create viable, domestic, secondary end-markets

- Create stable, predictable demand for recycled plastics that is separate from virgin markets (e.g., requirements for recycled content, taxes/fees on virgin resins)
- Improve the quality of recovered plastics at both the point of collection and in materials processing
- Improve access to domestic supply of recycled content
- Support innovation in product designs and uses for secondary plastics

Set 2: Get everybody onboard to collect all plastics

- Create sector-specific requirements for collection (e.g., extended producer responsibility, performance agreements)
- Restrict disposal (e.g., landfill taxes or bans)
- Require/incentivize collection (e.g., industry targets, deposit refund)
- Develop more consistent requirements and rules across Canada (e.g., common curbside recycling)
- Improve public information on collection and recyclability

Set 3: Support and expand all value-recovery options

- Support development of innovative value-recovery options, such as advanced mechanical and chemical recycling
- Focus primarily on improving mechanical recycling
- Increase the ease and speed at which new value recovery facilities can be developed by removing policy barriers and investing in innovation

Set 4: Increase efficiency throughout the value chain

- Facilitate collection and value-recovery by creating requirements for the reusability and recyclability of product design (e.g., standards and public procurement)
- Improve performance by investing in sorting and separation
- Educate and engage actors and consumers throughout the value chain

Set 5: Extend plastics lifetime to reduce and delay waste generation

- Leverage opportunities to extend the lifetime of durable goods, which account for approximately 51 percent of total plastics waste, but have a very low recycling rate (two percent) compared to that of non-durable goods (15 percent)
- Introduce measures that contribute to increased reuse, repair and remanufacturing (in particular with higher value durable goods such as EEE or white goods) such as standard requirements for reparability or reusability, and tax exemption to reduce and delay waste generation from durable goods in Canada

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List of acronyms

ECCC	Environment and Climate Change Canada
EEE	Electrical and Electronic Equipment
EPR	Extended producer responsibility is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products
EPRA	Electronic Products Recycling Association
HDPE	High Density Polyethylene
HS	Harmonized System codes
ICI	Industrial, Commercial, and Institutional sector
kt	kilotonne
LCA	Life cycle Assessment
LDPE	Low Density Polyethylene
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
PA	Polyamide
PE	Polyethylene
PET	Polyethylene Terephthalate
POP	Persistent Organic Pollutant
PP	Polypropylene
PS	Polystyrene
PU / PUR	Polyurethane
PVC	Polyvinyl Chloride
RRRDR	Remanufacturing, Refurbishment, Repair and Direct Re-use
StatCan	Statistics Canada
SUT	Supply and Use Table

Glossary of terms

Chemical recycling	Chemical recycling can be defined as a process changing the chemical structure of plastic waste, converting it into shorter molecules, ready to be used for producing new plastics or fuels
Depolymerisation	Depolymerisation refers to chemolytical processes that break down polymers and produce mainly the monomers from which they have been produced or other oligomers (short chains of monomers). These can then be used as building blocks for the production of new polymers
Diversion rate	See R1/COLL (see Section Model parameters)
Feedstock	Any bulk raw material that is the principal input for an industrial production process
Leakage	Materials that do not follow an intended pathway and 'escape' or are otherwise lost to the system. Litter is an example of system leakage.
Mechanical recycling	Operations that recover after-use plastics via mechanical processes (grinding, washing, separating, drying, re-granulating, compounding), without significantly changing the chemical structure of the material
Output recycling rate	See R3/COLL in Section Model parameters
Recycling	A general term covering the process chain of collection, sorting, reprocessing of end-of-life materials into raw material that can be used as an input into new product manufacturing
Remanufacturing	Remanufacturing and comprehensive refurbishment are intensive, standardized industrial processes that provide an opportunity to add value and utility to a product's service life
Repair, refurbishment and arranging direct use	Repair, refurbishment and arranging direct use are maintenance processes that typically occur outside of industrial facilities and provide an opportunity to extend the product's useful life
Reprocessing yield	See R3/R2 in Section Model parameters
Resin	A natural or synthetic solid or viscous organic polymer used as the basis of plastics, adhesives, varnishes, or other products
Re-use	Action or practice of using something again, whether for its original purpose or to fulfill a different function
Reverse logistics	Process of moving goods from their typical final destination for the purpose of capturing their value, or for their proper disposal
Sorting	Waste sorting is the process by which waste is separated into different elements. In the context of this study, it refers to the separation of plastic material in recovery (or "sorting") facilities
Sorting yield	See R2/R1 in Section Model parameters
Value recovery rate	Share of plastic that is ultimately value recovered whether through chemical or mechanical recycling from diverted and disposed waste or through thermal recovery, divided by plastics in waste collected. This rate is equal to (R3+D-CHEM+D-EFW)/COLL (see section Model parameters)

White goods	In this study, white goods refer to appliances (large or small), which are machines in home appliances used for routine housekeeping tasks such as cooking, washing laundry, or food processing and preservation

Model parameters

COLL	Plastics in waste collected, either to be sent to a sorting facility (R1) or to disposal (D1) (Deloitte, 2019a)
D	Total plastics in waste sent to disposal. Some recovery can occur whether through chemical recycling (D-CHEM) or incineration with energy recovery (D-EFW). The rest either is incinerated without energy recovery (D-INC) or landfilled (D-LANDF) (Deloitte, 2019a)
D1	Plastics in waste sent to disposal (Deloitte, 2019a)
D2	Plastics in waste sent to disposal by MRFs. Represents the fraction rejected by the sorting facilities (Deloitte, 2019a)
D3	Plastics in recycling waste sent to disposal. Represents the fraction rejected by the recyclers (Deloitte, 2019a)
D-CHEM	Chemically recycled plastic from disposed waste (Deloitte, 2019c)
D-EFW	Plastics in disposed waste incinerated with energy recovery (Deloitte, 2019c)
DELT	The in-use delta measures the difference between the plastic products generation for a given product category in a given year and the estimated plastic waste generation of that same product category for the same year, before taking into account any additional re-use (see R-DELT below) (Deloitte, 2019a)
D-INC	Plastics in disposed waste incinerated without energy recovery (Deloitte, 2019c)
D-LANDF	Plastics in disposed waste sent to landfill (Deloitte, 2019a)
E2	Plastics in bales and sorted waste exported (Deloitte, 2019c)
GEN	Quantity of plastics in products generated in Canada (Deloitte, 2019a)
I2	Plastics in bales and sorted waste imported (Deloitte, 2019c)
LEAK	Plastics leaked permanently into the environment (Deloitte, 2019a)
QUANT	Quantity of plastics discarded, represents the plastic entering waste streams (Deloitte, 2019a)
R1	Plastics in waste diverted and sent to domestic MRFs (Deloitte, 2019a)
R1/COLL	Diversion rate, or the share of plastic diverted from direct disposal and sent to a sorting facility, divided by COLL. This rate is assessed per sector (Deloitte, 2019a)
R2	Plastics in bales and sorted waste sent to domestic recyclers (Deloitte, 2019a)
R2/COLL	Output sorting rate, or the share of plastic sorted by sorting facilities and sent to a reprocessing facility, divided by COLL. This rate is assessed per sector (Deloitte, 2019a)
R2/R1	Sorting yield, or the amount of plastics MRFs were able to sort out and send to reprocessing facilities, divided by the total amount of unsorted plastic received. This yield is affected by the quality of input waste material, contamination, type of plastics received, sorting technologies and equipment etc. It illustrates the efficiency of the sorting operations, and is assessed per waste stream category or sector (Deloitte, 2019a)
R3	Recycled plastic from diverted waste (Deloitte, 2019a)
R3/COLL	Output recycling rate, or the share of plastic that is ultimately reprocessed whether through chemical or mechanical recycling from diverted waste, divided by COLL. This rate does not include D-CHEM (Deloitte, 2019a)

R3/R2	Reprocessing yield, or the amount of recycled materials (flakes or pellets of recycled resins, monomers etc.) reprocessing facilities were able to produce and send to end-users, divided by the total amount of sorted plastics waste received from MRFs. It illustrates the recycling efficiency of the reprocessing operations, and is assessed per resin and technology (chemical or mechanical) (Deloitte, 2019a)
R3-CHEM	Chemically recycled plastic from diverted waste (Deloitte, 2019c)
R3-MECH	Mechanically recycled plastic from diverted waste (Deloitte, 2019a) (Deloitte, 2019c)
R-DELT	Direct re-use is a way to extend the expected end-of-use of products by a certain amount of time. As such, the re-use delta models the fact that a re-used product enters the waste stream later than an average non-re-used product (Deloitte, 2019a)
RRR	Plastics in repaired, remanufactured and refurbished products. Remanufacturing and comprehensive refurbishment take place within industrial or factory settings and result in quasi-new products, with a full-service life identical to a new product which production can thus be avoided (Deloitte, 2019a) (Deloitte, 2019b)

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1. The case for a zero plastic waste Canada

1.1 Plastic waste, a triple bottom-line challenge

Plastics are part of the everyday lives of most Canadians. Since the 1950s, global plastics production has increased more than any other manufactured material due to their low cost, durability and utility. However, the current ways in which plastics are managed throughout their lifecycle is threatening ecosystems, human health and livelihoods, and costing billions of dollars a year in lost economic value and other damages. In addition, the amount of plastic designed to be used once and then thrown away leads to a significant waste of resources and energy.

1.2 Canada is taking action

The Government of Canada has committed to work with its partners to move towards zero plastic waste with a vision of keeping all plastics in the economy and out of landfills and the environment. This represents an opportunity to grow Canada's economy while protecting the environment and reducing plastic waste, marine litter and greenhouse gas emissions.

1.3 Purpose of this report

Environment and Climate Change Canada commissioned this study to characterize plastic production, use and management in Canada and to identify the potential benefits, impacts, challenges and opportunities of transitioning to a zero plastic waste economy.

1.4 Scope and limitations of this report

This study is the first of its kind in Canada, presenting an entire lifecycle view (from production of virgin resins to the end-of-life of plastic waste) of most key plastics, both thermoplastics and thermosets. Thermoplastics are plastics that can be heated, cooled and reshaped repeatedly, while thermosets are plastics that can only be shaped once because their polymerization creates a three-dimensional network that cannot be remelted or solubilized.

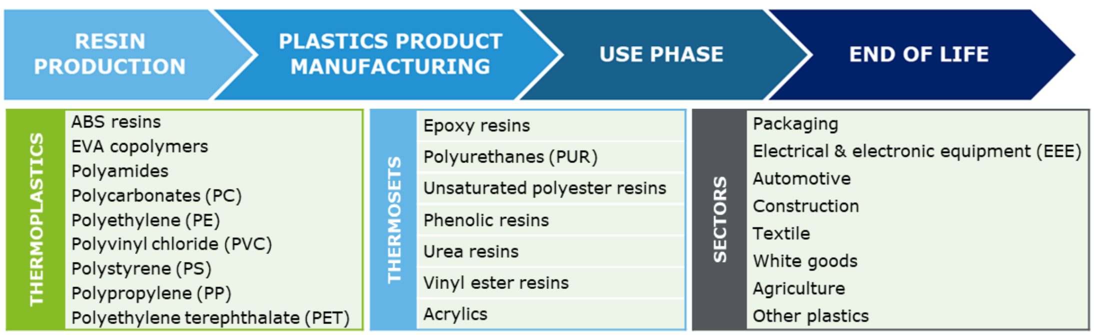
The lifecycle of plastics in the Canadian economy was broken down into four stages: resin production, plastic product manufacturing, use phase and end of life.

For each stage, a baseline economic assessment was conducted, looking at domestic production, import and export.

The various plastics products produced or traded in the Canadian economy were grouped into eight end-use sectors, defined for the purpose of this study: packaging, construction, automotive, electrical and electronic equipment, textiles, white goods, agriculture and other plastics. Together, these products covered an estimated 88 percent of plastics contained in products reaching the Canadian market annually.

Figure 4 illustrates the scope of the study from a lifecycle, resin and sector point of view.

Figure 4: Lifecycle stage, resins and sectors included in the scope of this study

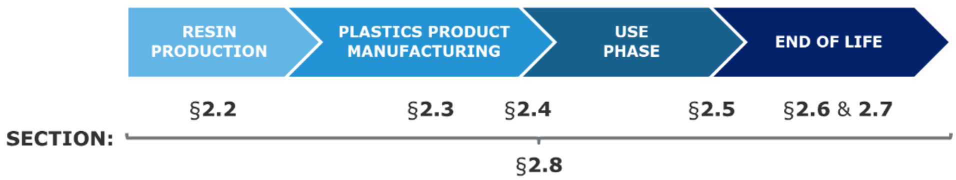


Unless stated otherwise, 2016 is the baseline year for the data presented in this report.

Scenario projections were also made for 2030, based on the situation in 2016 and several assumptions. An overview of the methodology followed to produce this study, as well as definitions of sectors and terms used is provided in Section 5 of this report.

2. Canada throws away 87 percent of plastics, valued at CA$7.8 billion

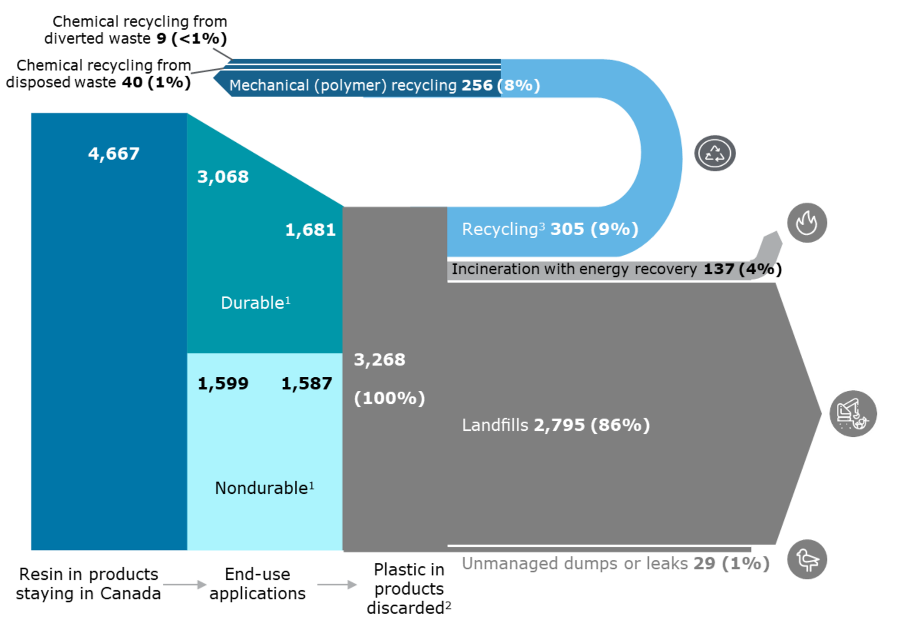
This section presents the key takeaways of the lifecycle of plastics in the Canadian economy. While Section 2.1 introduces the key findings from the overall lifecycle, Sections 2.2 to 2.7 explore in more detail the specific life cycle stages, and Section 2.8 concludes with end-use sector specificities.



2.1 The Canadian plastics economy is designed to be linear and to throw away plastic

In 2016, an estimated 3,268 kilotonnes (kt) of plastics was discarded as waste in Canada, out of the 4,667kt of plastics introduced to the market through both domestic and imported products. Only nine percent of these plastics were ultimately recycled (mechanically or chemically) and four percent were incinerated for energy recovery. The rest was landfilled (86 percent) or lost to the environment (unmanaged dumps or leaks; 1 percent), representing a value loss of CA$7.8 billion, based on the original value of the raw material (Figure 5).

Figure 5: Canadian resin flows in thousands of tonnes per annum, 2016



[1] Durable applications with an average lifetime >1 year will end up as waste only in later years; given market growth and increase share of plastics in durable applications (e.g., construction, cars) plastics waste generated today is less than what is being put in the market that same year. On the contrary nondurable applications go almost straight to waste.
[2] 1,587 thousand metric tons of mixed plastic waste from nondurable applications plus 1,681 thousand metric tons of mixed plastic waste from production in previous years.
[3] Output recycling rate, after taking into account process losses.

2.2 Canadian resin production geared towards virgin resin

With a production value of approximately CA$10.1 billion in 2017, virgin resin production accounts for the vast majority of the resins used by plastic producers and manufacturers. The industry is concentrated, mostly in Ontario and Alberta, with 87 companies producing 4,800kt of plastics resins and employing 4,000 people.

RESIN PRODUCTION

Virgin resins

CA$10B
in sales

4,000
Employees

87
Companies

Domestic production is specialized in high-volume thermoplastic resins, which represented 4,281kt in 2017, with a value of CA$8.2 billion. Polyethylene accounts for the majority of this production, with approximately 3,700kt produced in 2017. Other major thermoplastics include polyvinyl chloride (PVC, 210kt), polyethylene terephthalate (PET, 144kt), polyamide (PA, 95kt), polystyrene (PS, 80kt) and ethylene vinyl acetate (EVA, 53kt). Conversely, thermoset resins production in Canada represented 532kt in 2017, with a value of CA$1.9 billion. Four types of thermoset resins comprise the majority of production, including urea resins (204kt), phenolic resins (150kt), polyurethanes (123kt) and unsaturated polyesters (55kt).

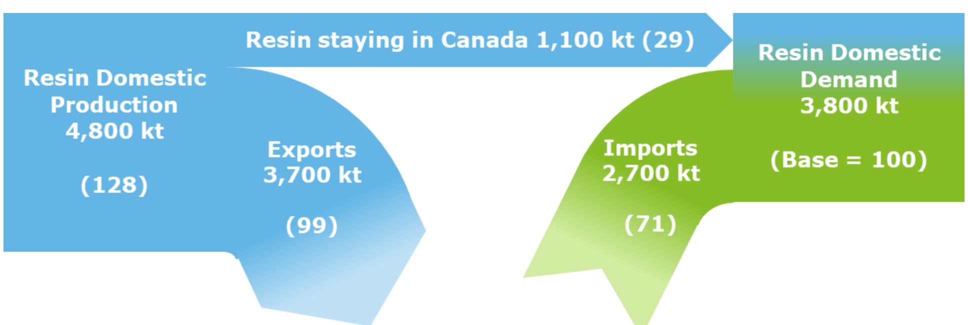
Virgin plastic resin production is dependent primarily on oil or natural gas for its source of chemical raw materials. The abundance of new, inexpensive energy sources resulting from shale gas development has precipitated unprecedented investment in new virgin resin production capacity. These investments are often vertically integrated and use the latest and most efficient technologies. This is expected to lead to an increase in the production of virgin resins in the near future, while potentially resulting in lower virgin resin prices (see blue box).

Price of virgin resins

Recently the prices of virgin plastic resins have experienced significant fluctuations. One reason for this was fluctuations of oil prices, with a sharp fall early in 2014 followed by a gradual recovery. The price of plastic resins (aggregate index) has followed a pattern that is very close to that of oil prices.

The virgin resin industry has a high level of international trade exposure, with 77 percent of the domestic production exported and 71 percent of the domestic demand fulfilled by imports (Figure 6). The US is a key trading partner, controlling more than 80 percent of the import and export share of the industry.

Figure 6: Virgin plastic resin production, demand and international trade in Canada (2016, kt) and relative share (base 100)



In comparison, the secondary market for recycled plastic resins is much smaller. In 2016, it is estimated that approximately 256kt of post-consumer plastics (mostly PET, PE and PP) were mechanically recycled in Canada, i.e., slightly more than five percent of the domestic virgin resin production. Representing approximately CA$350 million in annual revenues and 500 employees across its ten largest facilities, mostly located in Ontario, Québec, and British Colombia, the sector is however not as well documented as its virgin counterpart as it lacks some basic statistical and trade information (e.g., no specific import/export data for recycled resins).

Recycled resins

CA$350M
in sales

500
Employees

60
Major facilities

2.3 Plastic product manufacturing, a first step before integration into more complex finished products

PLASTICS PRODUCT MANUFACTURING

Plastic product manufacturing is a growing sector of the Canadian economy. In 2017, sales from Canadian plastic manufacturers, sustaining 89,000 jobs, reached CA$25 billion. While this amount represents only four percent of the sales of the manufacturing sector, plastic manufacturing is its fastest growing segment experiencing an average annual growth rate of 5.5 percent between 2012 and 2017. The industry has a large pool of small and medium companies, operating approximately 1,845 establishments throughout the country, especially in Ontario, Quebec and Alberta.

Plastic product manufacturing has a high level of international trade exposure; in 2017, exports reached CA$10.2 billion, almost 40 percent of domestic output, and imports reached CA$12.3 billion, fulfilling approximately 45 percent of the domestic demand (Figure 7).

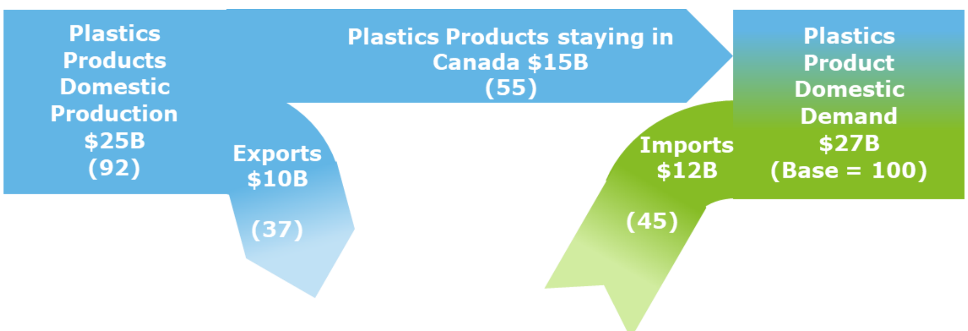
Plastics products manufacturing

$25B
in sales

89,000
Employees

1,845
Establishments

Figure 7: Canadian plastics products production, demand and international trade (2017, CA$) and relative share (base 100)



The sector demonstrates growing labour productivity with an average annual growth rate of 2.6 percent over the last five years. A large share of Canadian producers (63 percent) participate in the export market, which likely increases producers' competitiveness. However, the sector also faces challenges given the limited scale of production establishments, low investments in research and development, currency and commodity risks, and lack of skilled workers; similar to other sectors, plastic manufacturing also faces the challenge of future technological changes. Finally, as two inputs, price of plastic resins (26 percent) and labour (24 percent), account for half of the total costs of plastics manufacturing, sharp fluctuations in the price of oil can influence the price of plastic products.

A first step in the value chain of more complex products

93 percent of domestic demand for plastics products is driven by companies, which mainly use plastics products as intermediary components to incorporate into their final products or for their packaging.

Companies that mainly use plastics products as intermediary components to incorporate into their final products drive 93 percent of domestic demand. Among the top products sold by the plastic products manufacturing industry are motor vehicle plastics parts (CA$4.3 billion), plastic packaging material and unlaminated film and sheet (CA$5.5 billion), and plastic pipe and pipe fitting and unlaminated profile shape (CA$1.6 billion). Typically, these products will be further integrated into more complex finished products (e.g., cars, homes), or used as packaging of other goods.

Again, the US is the key trading partner, accounting for more than 90 percent of exports, and is responsible for over 60 percent of imports of the industry.

2.4 Few plastics products are designed with their Canadian use phase and end-of-life in mind

USE PHASE

Covering 88 percent of all resins, this study tracked products containing plastics throughout the Canadian economy, taking into account both domestic production, imports and exports of intermediate and final products. This led to the estimate that approximately CA$13 billion worth of resins, i.e., 4,667kt of plastics, were introduced to the Canadian market in 2016. As resins follow the import and export of intermediate (e.g., plastic motor vehicle parts) and final products (e.g., cars), few products containing plastics are designed with their Canadian use phase and therefore their Canadian end-of-life in mind (Figure 8).

Figure 8: Flows of resins in products containing plastics (2016 extrapolation based on 2014 Supply and Use Tables, CA$) and relative share (base 100)

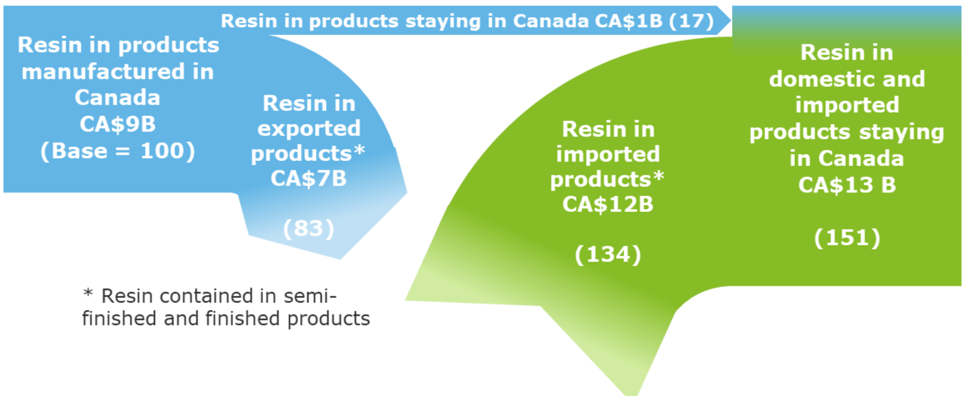
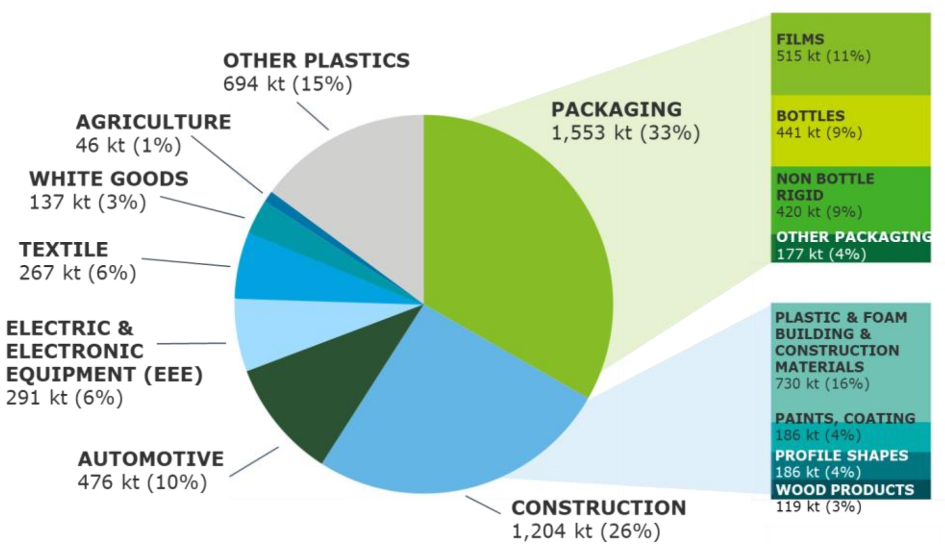


Figure 9 illustrates the end-use markets for plastics in those products staying in Canada. Three sectors (see blue box on the right) account for nearly 70 percent of plastic use: packaging, construction, and automotive.

Figure 9: End-use markets for plastic products in Canada (kt, 2016)



Sectors

Products containing plastics were grouped into eight "sectors" developed for the purpose of this study: packaging, construction, automotive, electric and electronic equipement, textile, white goods, agriculture and other plastics.

Section 5.2 provides details on the products grouped into each sector.

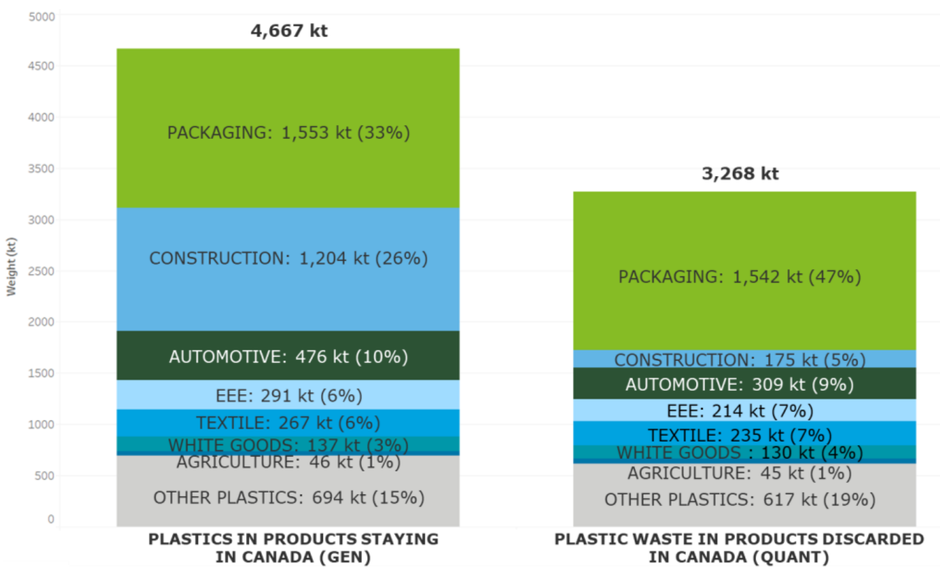
2.5 Packaging applications driving plastic waste, at least for now

END OF LIFE

Durable applications with an average lifetime over a year will end up as waste only in later years. Given the market growth and increased share of plastics in durable applications (e.g., construction, cars), plastics waste generated today is less than what is being introduced to the market that same year. Conversely, nondurable applications go almost straight to waste.

This means that, while packaging accounted for 33 percent of plastics introduced to the market in 2016, it accounted for 47 percent of all plastic waste discarded that same year (Figure 10). In coming years, the profile and quantity of plastics waste will progressively adjust to reflect the quantity of plastic waste from durable applications introduced to the market today, in particular with an increasing plastic waste stream coming from the construction sector, in which products have the longest average lifetime (between 15 and 25 years).

Figure 10: Plastics entering the market and plastics discarded in Canada (kt, 2016)



More plastic waste to come

In 2016, 43 percent more plastics entered the market in Canada (4,667kt) than plastic waste discarded in the same year (3,268kt).

2.6 Only 25 percent of plastic waste is collected for diversion

Once discarded in various products, plastic waste can be either collected for direct disposal (i.e., to be sent to landfills) or collected for diversion (i.e., diverted from direct disposal and sent to a sorting facility). The collection of plastic waste for diversion (e.g., through curbside collection, recycling depots, deposit-refund systems, etc.) is highly dependent on the end-use sector. As illustrated in Table 1, only 25 percent of all plastics discarded are collected for diversion (i.e., 807kt collected out of the 3,268kt discarded).

Table 1: Diversion rate broken down by sector, 2016

Sector	Plastics discarded[1] (kt)	Diversion rate[2] (%)	Plastics diverted[3] (kt)
Construction	175	11	19
EEE	214	16	34
Packaging	1,542	23	347
Textile	235	5	11
Automotive	309	100	308
White goods	130	64	83

Sector	Plastics discarded[1] (kt)	Diversion rate[2] (%)	Plastics diverted[3] (kt)
Agriculture	45	9	4
Other plastics	617	0	0
Total	**3,268**	**25**	**807**

[1] Quantity of plastics discarded representing the plastic entering waste streams (QUANT)

[2] Diversion rate is the share of plastic diverted from direct disposal and sent to a sorting facility divided by plastics waste available for collection (R1/COLL)

[3] Plastic diverted from direct disposal and sent to a sorting facility (R1)

[1,2,3] See Section 5.3 for more details on the plastic waste management model and its underlying assumptions.

There are several contributing factors to the low diversion rate for end-of-life plastics in Canada. Some of the most important contributing factors are included in Table 2.

Table 2: Contributing factors to the low diversion rate in Canada

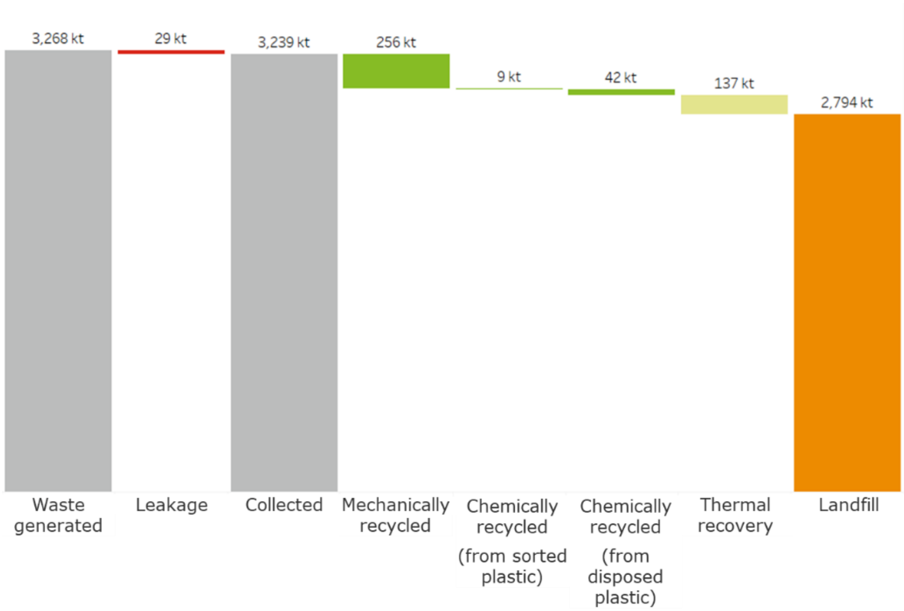
Area	Factors
Product design	• Continued poor adherence to available "design for recyclability" standards on behalf of many brand owners reduces the amount of end-of-life plastic waste that can be diverted to the recycling stream
Collection mechanisms	• Improper sorting at the consumer and collection level (e.g., increasing reliance on single-stream collection systems) results in the contamination of collected plastics. Additional sorting and quality control are thus necessary at material recovery facilities, and additional technologies to remove or mask a moving target of contaminants at plastic recycling plants • The realities of the geography of Canada, in which plastic consumption is distributed over a wide area (e.g. end-of-life agricultural plastics) limits the ability to establish comprehensive and cost-effective collection systems
Collection from ICI	• There are low levels of end-of-life plastics collection from the industrial, commercial and institutional sectors, which generally fall outside of established municipal collection systems
Infrastructure	• Current lack of robust infrastructure for chemical recycling or thermal recovery of end-of-life plastics limits the potential diversion routes for hard-to-recycle plastic material
Regulatory	• There is a lack of robust government intervention (as compared to other international jurisdictions) to force a greater level of diversion (e.g., landfill bans)
Economic and price signals	• Low virgin resin prices establish the ceiling at which recycled resins can be sold, impacting the amount of end-of-life plastic products that can be cost-effectively diverted for recycling • The cost of separating end-of-life plastics from certain waste streams is prohibitive (most notably for construction), especially when compared to other available management options (e.g., low landfill tipping fees) • General lack of markets for several recycled plastic resins from end-of-life plastics (e.g. polystyrene, plastic film, construction and demolition waste) limits most plastic recyclers from accepting/managing those materials

The above factors combine to form a system in Canada that does not provide the necessary incentives or outlets to divert plastics away from the disposal route for some end-of-life plastic streams and generators. Automotive and white goods are noticeable exceptions, as metals from end-of-life vehicles and large appliances provide additional incentive to collect these products. However, even in the case of end-of-life vehicles and white goods (although they are diverted), the plastics that are contained in these materials eventually ends up in shredder residue, which in Canada is disposed of in landfills (although often used beneficially as daily landfill cover). After collection, plastic waste has access to various value-recovery options, presented in Section 2.7.

2.7 Canadian value recovery options, focused today on mechanical recycling, are slowly expanding

There are various value recovery options for plastic waste, as illustrated in the waste management hierarchy (see box on the right). In 2016, three recovery options (i.e., mechanical, chemical and thermal) enabled the diversion of 13 percent of plastic waste from landfills in Canada. Figure 11 highlights that mechanical recycling is the first option for recovery, accounting for eight percent of plastic waste, followed by thermal recovery (four percent) and chemical recycling (one percent). This section describes the key elements of each option.

Figure 11: Waterfall view of total plastic waste over the lifecycle (kt, 2016)

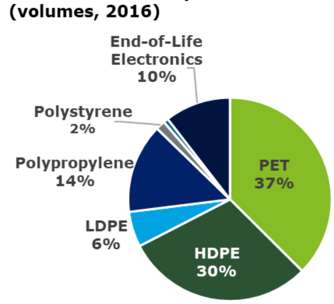


Remanufacturing, refurbishment, repair and direct reuse (RRRDR) is the first option in the waste management hierarchy, but the least present in Canada. Initiatives to reuse or repair certain products containing plastics (e.g., textiles, electronics, construction) exist, but remain fragmented and small scale in nature (and therefore are not included in Figure 11). The impact of these initiatives is difficult to quantify given that some (e.g., repair and direct reuse) temporarily reduce waste by keeping products in service for longer, while others (e.g., remanufacturing) provide a new lifetime to the material. Overall, several factors limit the development of RRRDR approaches in the plastic value chain, including:

- The dominance of linear business models, through which products are manufactured, distributed, consumed and then disposed of, with limited options for RRR. However, more circular oriented models are emerging, such as the function economy (through which companies sell a service rather than a product);
- There can be a negative tradeoff for the consumer/user, for whom it is generally cheaper to dispose and buy new products than to repair the old one;
- Products are often not repairable by design (voluntarily or not);
- The lack of mechanisms in place for reverse logistics, which jeopardizes the economic viability of RRR activities by adding collection and transport costs; and
- The replacement of plastics parts (e.g., casings, shells, or hulls) to provide new 'look and feel', even if a product is remanufactured.

Mechanical recycling is currently the main value recovery option utilized in Canada. The vast majority of post-consumer mechanical recycling economic activity occurs at approximately 10-11 facilities across Canada, which typically (but not exclusively) produce resins and/or flakes of multiple resins. These facilities primarily recycle PET, HDPE, LDPE and polypropylene, which almost exclusively originate from packaging. The main challenges faced by mechanical recycling operations include the continued low prices of virgin resins, low bale quality received from some municipalities resulting in higher operating costs and lower profitability, the prevalence of poor design decisions (from a recyclability standpoint) on behalf of brand owners, and increasing costs to transport bales from various municipalities to the recycling facility.

Resins mechanically recovered (volumes, 2016)



Improvements that could increase the amount of mechanically recycled post-consumer plastics in Canada include:

- Facilitating greater adherence to "design for recyclability" guidelines by brand owners to reduce the quantity of end-of-life plastics that cannot be recycled for technical and/or economic reasons;
- Ensuring a continued market for post-consumer resins, irrespective of potential reductions in the price of virgin resin (e.g., by mandating post-consumer content in some plastic products);
- Encouraging municipalities to enter long-term contracts with Canadian recyclers, thereby ensuring raw material availability for these recyclers and the resulting stability to invest in plants and equipment; and
- Fostering a collection and separation system that reduces the contamination of post-consumer plastic bales.

Despite these potential improvements, there are limits to the increase in plastic waste that the system can manage. The fact remains that some end-of-life plastics cannot be cost-effectively recycled mechanically (i.e., the post-consumer resin that is produced would have to be priced much higher than virgin resins). In other instances, there is simply no market (or the market is not sufficient) to sell the post-consumer resins that are produced. This was a major contributing factor to the Canadian export of certain end-of-life plastic streams overseas for processing, as there was a very small or non-existent North American market for these resins.

Chemical recycling of plastic waste is the process of converting plastic waste into shorter molecules, for use in the production of new plastics or fuels. From a circular economy perspective, the utilization of chemical recycling technologies to produce new plastic resins would be preferred. However, at present the companies that operate these types of facilities in Canada are generally managing small quantities of post-consumer plastics. Conversely, chemical recycling facilities that are producing fuels from end-of-life plastics are managing much higher quantities of plastic waste. Although still in the emerging phase, chemical recycling is recognized as being a potential outlet for end-of-life plastics that cannot be mechanically recycled due to technical, economic or market considerations. Developing technologies are creating a new market and offering innovative outputs for plastic waste. Further, they offer an additional source for plastic producers or for other industries if the recycling process includes a polymerization phase or a dissolution. Chemical recycling could bring new solutions to the sorting issue by accepting "lower quality" or mixed input, such as shredder residues from the automotive, EEE, or White Goods sectors. Furthermore, actors in the private and public sector view chemical recycling as an opportunity to respond to societal expectations in terms of "closed-loop" economy. Enhancing or investing in these technologies could help address mixed plastics treatment on a large scale through projects with greater acceptability (versus waste-to-energy plants). Six companies in Canada have commercialized or are nearing commercialization of chemical recycling processes using waste plastics as feedstock. However, several of these technologies still need to be scaled up, or demonstrate commercial viability.

Composting is an option that has been explored in Canada, but very little post-consumer plastic is managed through industrial composting facilities, with biodegradable and compostable plastics often considered a nuisance by industrial composting operations. There is no labelling requirement, standardized chemistry or standardized degradation time for biodegradable plastics, and even certified compostable plastics are not accepted by many composting facilities in Canada due to the differences between the certification requirements and their operating conditions.

Incineration with energy recovevy (also called waste-to-energy or thermal recovery) is the second most prevalent value recovery option for managing plastic waste in Canada, with 137kt treated in 2016. The vast majority of these plastics are thermally recovered at Canada's five waste-to-energy plants, but other facilities such as steel and cement manufacturing plants could use plastic for energy (volumes used in these applications are estimated to be low). Plastics are valuable fuels because they are made with petroleum and generate energy when incinerated. Waste-to-energy (as well as cement) facilities accept all kinds of plastics, including currently unrecyclable resins such as thermosets and mixed plastics, and thus offer interesting avenues for treating waste from certain sectors. However, due to the substances released during incineration (e.g., dioxins, furans, heavy metals, and volatile organic compounds) waste-to-energy facilities typically have significant public opposition to their construction and/or expansion. It may therefore be difficult to expand upon Canada's current infrastructure of waste-to-energy plants to provide more outlets for increased value recovery of hard-to-recycle plastics. All five of Canada's current waste-to-energy facilities are operating at full capacity and generally are not allowed to accept waste materials from outside of their jurisdiction. Currently, there are no known new waste-to-energy plants being considered in Canada.

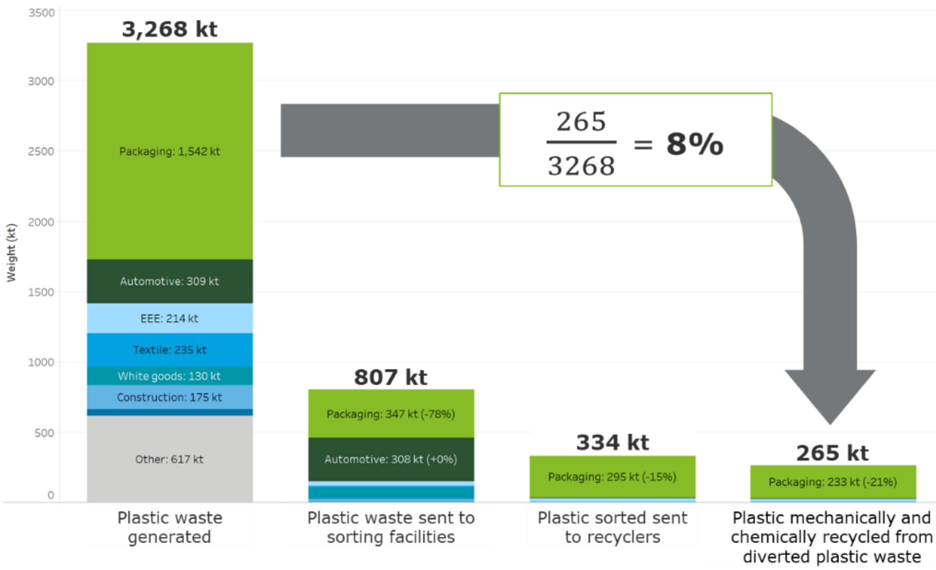
Following Section 2.8 presents sector specificities concerning plastic waste management in Canada.

2.8 Value recovery performance, drivers and challenges vary greatly by sector

The overall value recovery rate (which includes mechanical and chemical recycling from disposed and diverted waste, as well as thermal recovery) for plastics reached 13 percent in 2016 in Canada. However, the situation varies greatly between the eight sectors defined for the purpose of this study (see Section 5.2).

Figure 12, while focused on only one value recovery option (i.e., recycling from diverted plastic waste), illustrates already some of those major differences and in particular the specific role of packaging which accounts for 88 percent of all plastics resins recycled.

Figure 12: Plastic at different stages of the waste life cycle, per sector (kt, 2016)



Source: (Deloitte, 2019a). Please refer to model introduced in Section 5 to identify data in recycling value chain

Further, and based on a comparative analysis of their performance rates and yields (see Table 3), the eight sectors were clustered into four distinct groups: plastics from packaging; plastics in other products targeted by extended producer responsibility (EPR) systems; plastics collected but discarded; and untargeted plastics. Key characteristics of each group are presented in this section.

Table 3: Diversion rate, recycling rate and value recovery rate, per sector, 2016

Sector	Plastics discarded[1] (kt)	Diversion rate[2] (%)	Recycling rate[3] (%)	Value recovery rate[4] (%)	Plastics recovered[5] (kt)
Packaging	1,542	23	15	21	327
EEE	214	16	13	15	33
Agriculture	45	9	5	10	5
Automotive	309	100	0	0	0
White goods	130	64	0	5	7
Construction	175	11	1	6	11
Textile	235	5	0	7	17
Other plastics	617	0	0	7	43
Total	**3,268**	**25**	**8**	**13**	**442**

[1] Quantity of plastics discarded representing the plastic entering waste streams (QUANT)

[2] Diversion rate is the share of plastic diverted from direct disposal and sent to a sorting facility divided by plastics waste available for collection (R1/COLL)

[3] Output recycling rate is the share of plastic that is ultimately reprocessed whether through chemical or mechanical recycling from diverted waste, divided by plastics waste available for collection (R3/COLL). This rate does not include chemical recycling from disposed waste (D-CHEM).

[4] Value recovery rate, or share of plastic that is ultimately value recovered (whether through chemical or mechanical recycling from diverted and disposed waste or through thermal recovery), divided by plastics in waste collected. This rate is equal to (R3+D-CHEM+D-EFW)/COLL

[5] Quantity of plastics recovered through chemical or mechanical recycling from diverted and disposed waste or through thermal recovery (R3+D-CHEM+D-EFW)

[1,2,3,4,5] See Section 5.3 for more details on the plastic waste management model.

Plastics from packaging

Plastics from packaging (e.g., films, bottle, non-bottle rigid) represents 1,542kt or 47 percent of all plastic waste generated in Canada in 2016. Overall it is the first source (74 percent) of value recovered plastics with 327kt. Its 21 percent value recovery rate is supported by the highest recycling rate among all sectors, 15 percent. Packaging is targeted by several EPR and other programs, such as deposit-refund systems for beverage plastic bottles, which are the main drivers for its fairly high diversion rate (23 percent). However this diversion rate is also limited due to multiple root causes, including (but not limited to) lack of collection infrastructure away from home and lack of acceptance of many products by curbside collection. Most plastics used in packaging (e.g., PET, PE, PP) have a high recyclability and are the focus of attention for recyclers given the relative high value of these resins on the secondary market. However, the dominance of single-use products, the variety of packaging design and materials (multi-laminate), the presence of additives or pigments also affects contamination of waste streams and overall profitability of plastics packaging value recovery.

Packaging

- First source of plastic waste generated (1,542kt in 2016)
- Highest value recovery rate: 21% (of which 15% through recycling)
- Pros: high recyclability and large utilization of thermoplastics, widely deployed curbside collection of recyclable goods, EPR and deposit-refund programs, efficient sorting technologies, relatively high value of resin recycled
- Cons: lack of collection infrastructure away from home, not all products accepted by curbside collection, dominance of single-used products, multiplicity of packaging design and materials, presence of additives/pigments

Plastics in other products targeted by extended producer responsibility (EPR) schemes

In addition to the EPR systems applicable to packaging, several additional mandatory or voluntary EPR schemes exist in Canada, in particular for the EEE and agriculture sectors. They allow for partial collection and recycling of plastics waste within the targeted sector.

The Electronic Products Recycling Association (EPRA) operates programs across Canada to collect targeted electrical and electronic equipment products (e.g., computers, printers, display devices like television sets, audio/video systems and phones) and to send them towards recycling streams. Although plastic contained in EEE (mainly EPS, PP and ABS resins) is not specifically targeted by EPRA, it is nonetheless sorted and recycled through shredding operations and categorized within the mixed plastic stream (lower quality). Out of the 214kt of EEE plastic waste generated annually, 33kt or 15 percent are recovered (mainly through mechanical recycling: 26kt). This material is usually exported to Asia, although the number of countries that are still willing to accept shredded mixed plastic waste from EEE waste recyclers is becoming rapidly smaller.

EEE

- Half of plastics from EEE waste are targeted by a nationwide EPR system
- Value recovery rate: 15% (29% for EEE products targeted by EPR system)
- Pros: EPR system in place, wide access rate
- Cons: 33% diversion rate, low quality recycled plastics (shredded mixed material), shrinking end-market (Asia)

The agriculture sector has deployed five known voluntary EPR schemes on various product categories in several provinces in Canada. They target plastics used for grain and seed transportation bags, fertilizer and pesticide packaging, as well as agricultural films – mainly HDPE, LDPE and woven PP. Discussion with one stewardship organization indicated these EPR schemes are expanding year after year. In 2016, out of the 45kt of plastic waste generated by the agriculture sector, approximately 4kt is collected for diversion (nine percent), 2kt recycled (five percent), 2kt incinerated (waste-to-energy), and 40kt sent to landfills.

Agriculture

- Approximately 45kt of plastic waste generated annually
- Value recovery rate: 10%
- Pros: use highly recyclable plastics (PE, PP); several EPR system implemented
- Cons: scope and geography of EPR systems to be widened

Plastic collected but discarded

In the automotive and white goods sector (e.g., large appliances such as fridges or stoves as well as small household appliances like a food processor, electric kettles), the recycling of plastic is almost non-existent. Diversion rates are however very high (100 percent for automotive, 64 percent for white goods) as products are collected for recycling. However, they are usually sent to a shredder where only the material of interest (generally the metal content) is sorted and sent to recyclers. It is indeed more cost-effective and less labour-intensive to crush and shred vehicles or appliances for metal recycling than to dismantle parts, including plastic parts.

Automotive

- 1.6 million end-of-life vehicles are retired annually, or 309kt of plastic
- Almost no value recovery for plastics occurs. Shredded plastic used as cover/capping material for landfills
- Pros: opportunity for sorting (transit through auto-recyclers)
- Cons: low recyclability (plastic blends, contamination), no incentive to sort (cost, labour), absence of end-market for recycled resin

In the automotive sector, the quasi-absence of end markets for the plastic contained in cars, which are often blends or potentially contaminated by automotive fluids and additives, reduces the incentives for recyclers to explore this avenue.

In the white goods sector, the low presence of appliance manufacturers in Canada (whether to implement closed loop recycling, remanufacturing or re-use of spare parts) has an effect on the economic cost of disassembly. In addition, there are limited end markets for mixed shredded plastics. Combined, those two factors limit recycling of plastics from white goods.

White goods

- Recycling of white goods targets metal parts and not plastic
- Almost no recycling for plastics occurs, and shredded plastic is used as cover/capping material for landfills
- Value recovery rate: 5% through waste-to-energy
- Pros: diversion stream in place (large appliances)
- Cons: plastic parts of low interest for recyclers, high cost of disassembly, very small presence of appliance manufacturers in Canada

Thus, in these two sectors, plastic shows a good collection rate, but is turned into shredder residue and sent to landfills, usually as daily cover material. Despite this poor performance, the existing collection channels (through which the products and their plastic content get collected for diversion) represent an opportunity, with the right market signals, for increased recycling.

Untargeted plastics

Plastic waste from the last three sectors (e.g., construction, textile and other plastics) shows very low collection rate, sorting and reprocessing yields, either across the board or at one specific step of the value chain, leading to an overall quasi-null recycling rate. This situation stems from different reasons, including (but not limited to): hard to recycle plastics (e.g., blends, thermosets), contamination (e.g., problematic additives, dusts), and the absence of incentives to sort/recycle.

While construction sector is still a relatively small plastic waste generator (175kt or five percent), its share will progressively increase to reflect its current share of plastics introduced to the market in Canada (1,204kt or 26 percent, see Figure 10). As such this sector will likely play an increasingly important role in the overall performance of plastics value recovery in Canada.

Most value recovery in those three sectors occurs through incineration with energy recovery.

Construction

- Few plastics enter the waste stream (175kt) compared to plastics introduced to the market (1,204kt) and stocked in buildings
- Value recovery rate: 6% through waste-to-energy
- Pros: opportunity for sorting as waste transits through MRFs
- Cons: low recyclability (thermosets, contamination), no incentive to sort (on-site or at MRFs)

Textile

- Plastic waste from textile estimated at 233kt
- Value recovery rate: 7% through waste-to-energy
- Pros: reuse streams (e.g., salvation army) in place
- Cons: few/no specialized recyclers or end-markets known in Canada

Other sectors

- Very little to no information available
- Value recovery rate: 7% through waste-to-energy
- Pros: -
- Cons: represent 617kt annually

3. A zero plastic waste economy would deliver significant benefits to Canada

3.1 A zero plastic waste economy by 2030

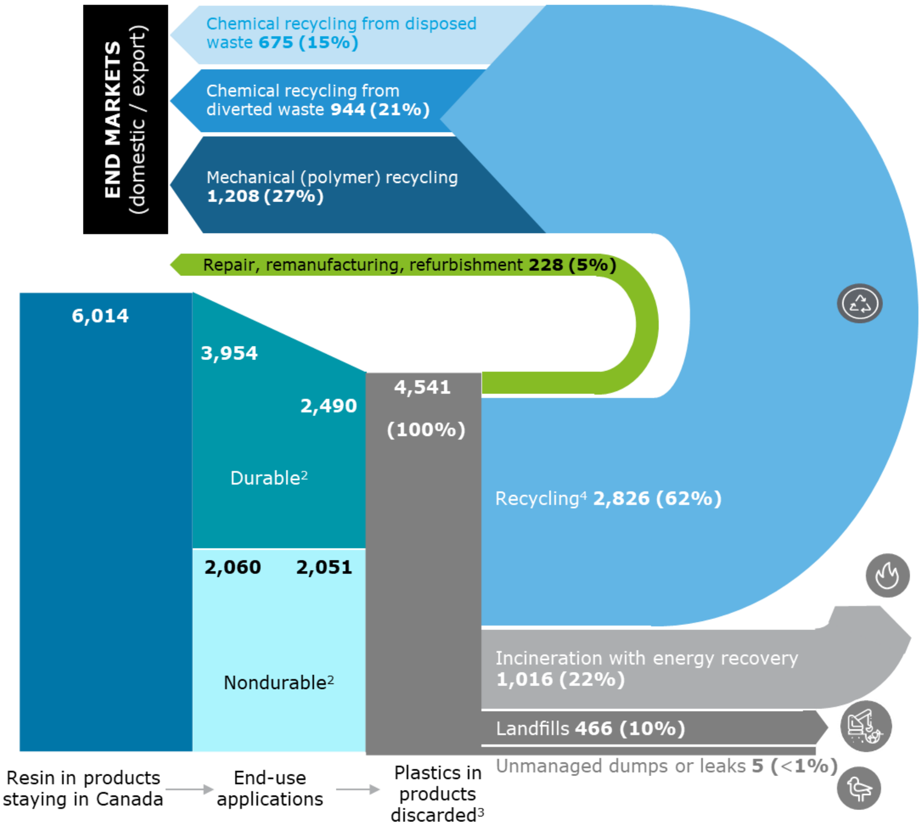
To illustrate a different future for plastic management in Canada, the authors developed two plastic waste management scenarios at the **2030 horizon**[1]:

- A business as usual scenario (2030_{BAU}), taking into account a generic market growth for all sectors and keeping the same performance parameters as the 2016 baseline (Figure 5 in Section 2); and
- An ambitious scenario (2030_{T90}) in which the overall system performance leads to the diversion from landfill of 90 percent of the discarded plastic waste (Figure 13).

The ambitious scenario is not a not a prediction or a recommendation: it is an illustration of what zero plastic waste could look like given current product designs and emerging value recovery technologies. It was developed to model the potential costs and benefits of achieving zero plastic waste if the plastic production and end use applications remain unchanged from 2016. Changes in plastic production and design would open the door to a very different scenario with higher value recycling and recovery options.

[1] While this Task 5 report presents only results associated with the 90 percent diversion scenario and its comparision with the business as usual one, another scenario illustrating a 50 percent diversion rate was also developed in Task 2 report (Deloitte, 2019b).

Figure 13: Canadian resin flows in thousands of tonnes per annum, 2030$_{T90}$ scenario[1]



[1] Scenario based on a multi-stakeholder push to boost recycling, including investment in new facilities, regulatory measures to encourage recycling, significant progress on technologies and favorable end-markets demand.

[2] Durable applications with an average lifetime >1 year will end up as waste only in later years; given market growth and increase share of plastics in durable applications (e.g., construction, cars) plastics waste generated today is less than what is being put in the market that same year. On the contrary nondurable applications go almost straight to waste.

[3] 2,051 thousand metric tons of mixed plastic waste from nondurable applications plus 2,490 thousand metric tons of mixed plastic waste from production in previous years.

[4] Output recycling rate, after taking into account process losses

While this ambitious scenario (2030$_{T90}$) represents a promising and potentially achievable future, it is based on systemic and far-reaching assumptions, which are presented in the next section.

3.2 A path towards a 90 percent diversion of plastic waste

A 2030 scenario based on a 90 percent diversion of plastics waste from landfill (2030_{T90}) can only be envisioned when coupled with a series of major systemic changes compared to business as usual, at all stages of the plastics value chain. To achieve the required increase to diversion rates for plastics waste in Canada, significant improvements in the quantities managed by the various value recovery options are required. The 2030_{T90} scenario was developed by first pushing mature technologies like mechanical recycling, then projecting chemical recycling development, and finally resorting to waste-to-energy. Technical, economic and market limits on the quantity of end-of-life plastics that can be mechanically recycled were considered first. Chemical recycling growth potential was then estimated, given its attractiveness from several viewpoints (i.e., circular economy, management of hard-to-recycle plastic waste, public perception) and the presence in Canada of several entrepreneurial firms that have developed market-ready and/or proven chemical recycling technologies.

Key assumptions underlying the 2030_{T90} scenario are presented in three tables. First, Table 4 presents the key end of life assumptions for 2030_{T90}.

Table 4: Key end of life assumptions for 2030_{T90}

End of life of plastic waste	Change from 2030_{BAU} to 2030_{T90}	Key assumptions and rationale
Plastics leakage into the environment	From 1 percent to 0.1 percent	Plastic leakage (i.e., permanent litter) reduced ten-fold because of increased awareness from consumers and initiatives from public/private sector actors to reduce litter.
Repair, remanufacturing and refurbishment (RRR)	From <1 percent to 5 percent	RRR levels rapidly scaled in sectors in which RRR activities already exist in other jurisdictions (e.g., white goods and EEE sectors).
Mechanical recycling	From 7 percent to 27 percent	Mechanical recycling quadrupled due to improved (or maintained in the context of increased volumes) sorting and reprocessing yields, and scale-up of the number of facilities. This is the target scenario proposed by industry associations in Canada.
Chemical recycling	From 1 percent to 36 percent	Chemical recycling facilities scaled up following increased recycling activity, based on technologies currently developed in Canada (e.g., monomer recycling for PET/PA, building block recycling for PS/PE, pyrolysis to generate liquid feedstocks/fuels from disposed waste).
Incineration with energy recovery	From 4 percent to 22 percent	Incineration with energy recovery, while not a preferred option to recover plastic waste, is scaled (as a necessary recourse) to meet the 90 percent diversion target. This increase could be supported by additional facilities and by having existing industrial facilities (e.g., cement kilns) accept more plastics.

Second, the end of life assumptions above are based on additional assumptions regarding the entire recycling value chain (Table 5). Those assumptions represent significant efficiency improvements at each key step of the value chain and take into account an analysis of the value recovery technologies and their readiness level. In particular, chemical recycling technologies, which in Canada range from pilot to larger scale commercial, were significantly factored in to be able to reprocess the increased projected volume and diversity of resins present in the Canadian mix.

Table 5: Key recycling value chain assumptions for 2030_{T90}

Recycling value chain step	Change from 2030_{BAU} to 2030_{T90}	Key assumptions and rationale
Diversion rate	From 25 percent to 77 percent	Multi-stakeholder (consumer, industry, government) push to collect more plastics waste for diversion. Sector assumptions pushed to their maximum given sector specificities, including a major a push from 23 percent to 90 percent in packaging.
Sorting yield	From 40 percent to 82 percent	Increased sorting of plastics within diverted waste, in particular for waste from sectors that do not currently focus on plastics, such as automotive, white goods, and textile.
Reprocessing yield	No change (maintained at 79 percent)	Maintained reprocessing yield (chemical and mechanical) in the context of an additional amount of sorted plastic waste, including harder-to-recycle resins.
End-markets	A viable and stable domestic end-market for secondary plastics is developed	End-markets exist for all secondary plastic products and their by-products at a viable price point, which means either favourable virgin resin price and/or the development of a viable decoupled secondary plastics market. The quality of recycled plastics is broadly comparable to virgin resins.

Third, the significant expansion of all value-recovery options assumes support for the development of new facilities. The model projects the need to add 167 facilities for a total estimated investment of between CA$4.6 billion and CA$8.3 billion for 2030_{T90}, broken-down by facility types (Figure 14).

Figure 14: Additional capacity and investment estimates, 2030_{T90}

This estimate is based on:

- Additional waste processing capacities required in future scenarios compared to the current situation (2016 baseline);
- Average size of waste processing facilities; and
- Investment cost proxies, specific to four key step of the waste processing system: sorting, recycling of diverted waste (based on mechanical recycling estimates), chemical recycling from disposed waste and incineration with energy recovery. Landfilling capacities in 2016 were estimated to be sufficient for 2030 requirements under the scenarios considered.

Assumptions and values used for these estimates (Table 6) are based on recent investments for the various facilities and their feedstock composition.

Table 6: Capacity and investment requirement key assumptions

Type of facility	Facility average capacity (in kt of plastics waste)	Investment cost (low-high range, $/t[2])
Sorting	45 kt/y	750–1,200
Mechanical / chemical recycling from diverted waste	35 kt/y	400–1,200
Chemical recycling from disposed waste	30 kt/y	1,000–1,300
Energy from waste	106 kt/y	1,400–2,000

Source: (Deloitte, 2019b).

3.3 Benefits of a zero plastic waste economy by 2030

While the significant investment required to manage plastic waste under the 2030_{T90} scenario is reflective of the challenge Canada is facing, a comparative analysis between this scenario and business as usual demonstrates benefits from an economic, social and environmental point of view, as illustrated by Figure 15. These benefits should be considered in light of the investments required, as presented in Section 3.2.

Figure 15: Comparative analysis of scenarios

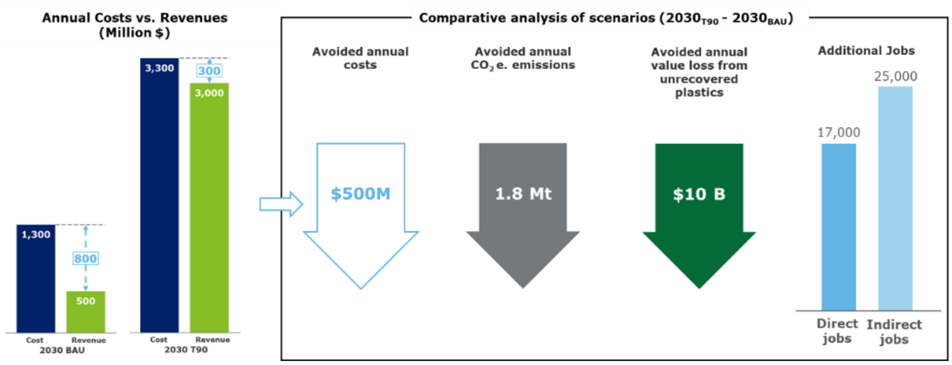


Table 7 presents the assumptions made for each area of the comparative analysis.

Table 7: Assumptions supporting the comparative analysis of scenarios

Comparison element	Change from 2030_{BAU} to 2030_{T90}	Key assumptions and rationale
Operating Costs	From CA$1,300 million to CA$3,300 million	Average costs per tonne of plastic going through each step of the recycling value chain were estimated based on available proxies and multiplied by material flows projected for both scenarios.
Revenues	From CA$500 million to CA$3,000 million	Price per tonne of recycled plastics along the value chain were estimated based on available proxies and reference points, and multiplied by material flows projected for both scenarios.
Direct jobs	From 10,000 to 27,000 direct jobs	Additional jobs in collection, sorting, and reprocessing counterbalance the losses in less labour intensive landfilling operations.
Indirect jobs	Same multiplier	Multiplier effect of 1.5 times each direct job.

[2] Per tonne of plastic waste (conversions have been made when facilities capacity was initially provided in tonne of MSW).

Comparison element	Change from 2030_{BAU} to 2030_{T90}	Key assumptions and rationale
CO_2 emissions across full lifecycle	From +0.2 to -1.6 Mt CO_2 equivalent (CO_2 e)	Avoided emissions through substitution of virgin resins with recycled plastic, offsetting direct emissions from other steps of the value chain, such as incineration with energy recovery.
Value loss from unrecovered plastics	From CA$11.1 billion to CA$1.4 billion	Value of unrecovered plastic (plastic sent to landfill or leaked into the environment) based on virgin resin prices.

3.4 Scenario implications for plastics markets

Achieving the 90 percent scenario would have impacts on the primary and secondary plastic markets. The increased quantity of recycled material (e.g., resin polymer, building blocks, monomers or feedstocks) could reach approximately 45 percent of plastics resin domestic demand. However, given the importance of international trade in the domestic plastics resins production sector, in particular with the US (see Section 2), it is difficult to forecast the final destination or usage of that recycled material. This material could be used to close the loop domestically by displacing imports or primary production, but it could also be exported, depending on several factors such as price, quality and demand for recycled material.

4. Canada needs an integrated approach to plastic management

Drawing the portrait of a 2030 scenario where 90 percent of plastic diversion is attained demonstrated that this goal could be realistic and drive significant benefits; however, this will require a concerted effort across several stakeholders in the public and private sector. It also demonstrated that Canadian society must implement radical changes to its current plastic management throughout the full lifecycle.

There is no single public or private sector action that can shift the system; international benchmarks from ten European jurisdictions, and examples from US and Australian case studies demonstrated that a systemic approach is needed, acting in several areas concurrently. A wide range of policies and approaches can be used to achieve these objectives, and this final section highlights those that have been effective in other jurisdictions.

4.1 Create a viable domestic secondary end-market

The main challenges of a secondary market are the lack of demand, low prices of secondary resins that compete with virgin resins, and the lack of supply. Thus, one of the most important actions that can be taken to encourage recycling is to create a reliable domestic market for collectors/processors/recyclers that is uncoupled from primary resin prices. As highlighted in Table 8, this could be accomplished by developing product-based quotas or requirements for secondary material content.

Table 8: Measures to support the creation of a viable domestic secondary end-market

Measure	Rationale
Product-based quotas or requirements for secondary material content	Creating a guaranteed stable domestic demand for secondary materials and subsequently increasing investment in plastics recycling/diversion. This could be thought of as the "first domino" that must be toppled to create cascading impacts on secondary plastics infrastructure investment and use. Certain products (bottles, certain packaging) that do not have difficult performance requirements (flame retardant, food-safe) could use secondary plastics of sufficient purity without significant issue.
Tax or fee on virgin resins	Introducing a tax or fee on virgin resins would make secondary plastic more economically appealing to manufacturers. However, the high volatility of oil price and the significant investment in virgin resin production would make that tax/fee hard to adjust in time to reach the desired effect. Further, it could lead to increased consumer prices.

Deployment of such measures could be progressive, beginning by targeting certain categories for which it is already technically and economically feasible. This requirement may be difficult to implement for imported products.

The creation of a reliable domestic market for collectors/processors/recyclers that is uncoupled from primary resin prices cannot be rolled out alone and should be accompanied with policies to:

- Improve the quality of recovered plastics at both the point of collection and in materials processing;
- Improve access to domestic supply of recycled content; and
- Support innovation in product design and use of secondary plastics.

4.2 Get everybody onboard to collect all plastics

Reaching a zero plastic waste goal will require major concerted efforts from all stakeholders of the value chain, including producers, retailers, consumers, recycling actors, and the public sector. As mentioned above, the recycling burden in Canada is currently concentrated within a few plastic product categories (e.g., packaging) and actors (e.g., residential consumers), resulting in the collection of only 25 percent of plastics. To trigger the systemic engagement of all parties, policy makers must consider several measures at different levels, such as illustrated in Table 9.

Table 9: Measures to support collection of plastics

Measure	Rationale
Requirements/incentives to participate in recycling	Widening recycling obligations/incentives to industries, commerce and institutions (ICI) is a first step to mobilizing the country towards a zero plastic waste goal. For example, policy makers can introduce differentiated recycling targets for plastic products (e.g., reduction targets for plastics in vehicles, rather than undifferentiated targets for all materials in vehicles), and deposit refund systems (through which an incentive is created to return/recycle a product).
Create sector requirements and mechanisms to support compliance	Approaches such as extended-producer responsibility (EPR) or performance agreements have the capacity to engage the entire value chain to rethink plastic usage. The most effective programs would target specific products and include standardization requirements, secondary material use requirements, and set trackable recycling targets.
Restricting disposal (e.g., landfill taxes or bans)	Whether they selectively target a specific product/sector or are broader, landfill restrictions or bans send a strong signal along the value chain, and require collective efforts. Providing significant lead-time between announcement and enforcement is necessary to ensure industry/governments have sufficient time to adapt and develop new infrastructure.
Directive or restrictions (e.g. bans) on specific products (e.g., *Single-Use Plastics Directive* in Europe)	These measures prevent the generation of problematic wastes in the first place. Although not always an option (e.g., automobiles), certain single-use plastics can be replaced with reusable alternatives, and taking action against certain single-use products could reduce the volume of plastic waste that must be managed.
Increased public awareness	Promote public awareness to enhance recycling program participation.

These measures have the potential to divert significant quantities of plastic waste from landfills. However, installed capacity to properly manage this influx of plastic waste is currently missing in Canada. Thus, prior to implementing the above-listed measures, policy-makers should consider the following:

- To ensure effectiveness, EPR programs should target specific products and include standardization requirements, secondary material use requirements, and set trackable recycling targets;
- When voluntary standards are in place (e.g., list of approved glues, labels, additives for specific applications), they appear to have no impact; regulators should ensure these standards are capable of achieving waste reduction; and
- Actions to expand the capacity of recovery options.

4.3 Support and expand all value-recovery options

The current value recovery options in place do not allow the recycling of all plastics. In order to reach the goal of 90 percent of plastic waste diverted from landfill, an estimated 167 new facilities will be required to collect, sort and treat this additional material, while diversifying treatment pathways (chemical and thermal in addition to mechanical). Government and policy makers at all levels have a key role to play to facilitate this expansion by removing policy barriers, investing in innovation to bring technology to scale and encouraging knowledge sharing, as shown in Table 10.

Table 10: Measures to support value-recovery

Measure	Rationale
Create grant or loan programs to develop collection, sorting, or reprocessing facilities	Facilitating access to investments.
Set product or waste stream targets for collection, recovery, and/or recycling	Leading jurisdictions have utilized targets for certain waste streams to encourage and support plastics recycling initiatives.
Undertake measures that make landfilling more expensive, or otherwise ban the landfilling of plastics	Increased materials diverted through recycling facilities.
Ensure consistent and clear standards and labelling to help establish further integrated North American recycling/reprocessing capacity	Ensuring consistent and clear standards to ensure that cross-border/inter-provincial trade benefits more efficiently the Canadian/US recycling sector.
Use taxes (lower VAT rate) or other financial instruments to stimulate demand for recycled plastics	Alleviating certain barriers such as uncertain return on investment, limited resilience to shocks, and resistance to change.
Identify emerging technologies that can be applied to overcome barriers to the recycling of certain problematic waste streams	Understanding the costs of these new technologies could help inform future policy decisions and strategies for handling plastics that contain additives of concern.
Develop waste-to-energy options to treat hard-to-recycle plastics	Supporting or developing high-volume alternatives (e.g., waste to energy, industrial use such as cement kilns) for those specific waste streams that are very low value and/or highly contaminated.

As plastic waste treatment capacity grows, it will require stable flows of materials to reach economic viability. Policy makers must concurrently implement approaches that will increase the amount of plastic waste diversion (upstream – see Section 4.2) while ensuring that secondary plastics markets exist (downstream – see Section 4.1).

4.4 Increase efficiency throughout the recycling value chain

With only 13 percent of plastics being diverted from landfill, efficiency increases are needed at all steps of the value chain. Losses are recorded at the collection (incorrect sorting at the consumer level), sorting (ability of MRF to sort waste with a low contamination rate and limited losses), and reprocessing (losses in the process, contamination of input material) stages. For Canada, increasing efficiency throughout the value chain means improving the productivity and accuracy of sorting, increasing the quantity of waste recycled, and decreasing the amount of mismanaged plastic waste.

In addition to the measures presented in the sections above, policy makers could take action at several levels, as presented in Table 11.

Table 11: Measures to support efficiency throughout the recycling value chain

Measure	Rationale
Product design guidelines	Facilitating downstream collection and value recovery by creating requirements for product design (e.g., systematic use of recyclable resins, lower use of additives, easy to disassemble products). Eco-designed products could be supported through standards and preference in public procurement. These guidelines would also facilitate reuse / repair / remanufacturing.
Investment in sorting	Increasing the efficiency of recycling by investing in new sorting technology, enabling more accurate sorting of different plastic streams.
Education	Educating and engaging actors and consumers throughout the value chain to increase awareness of recycling.

These efficiency improvements are necessary to achieve zero plastic waste in Canada, since several management avenues such as advanced mechanical recycling or chemical recycling function better with a low level of contaminants.

4.5 Extend lifetime to delay waste generation

By design, many durable products cannot be repaired. Yet, the longer products containing plastics remain in use, the later these plastics will enter waste streams. Furthermore, extending products' use life (including through remanufacturing) should lead to reduced demand for new products.

Although it will be difficult to reverse the trend towards single-use and disposable products, Canadian policy-makers can advocate for better quality products with longer average lifetimes. This can be supported through several approaches, as presented in Table 12.

Table 12: Measures to support product lifetime extension

Measure	Rationale
Discourage planned obsolescence	Create and communicate standards for product quality that would extend the effective life of the product by increasing the minimum legal warranty period for a given category of products or by introducing a "right to repair" that requires manufacturers to provide repair information, tools, and replacement parts to independent repair shops as well as product owners.
Encourage reuse, repair, remanufacturing and refurbishment	Explore financial incentives such as tax benefits/exemption to support repair activities and reuse of specific plastic product categories (often, disposing and buying new is cheaper than repairing, especially for low and medium-value items).
Education	Support communication campaigns that encourage repair and reuse, including labels (e.g., similar to energy star, specific labels could be developed to indicate product longevity).

4.6 Cross-cutting insights for successful implementation

The aforementioned approaches should be implemented in a concerted and systematic way, acting in several areas concurrently. However, international benchmarks from both European, US and Australian case studies have demonstrated that no "one size fits all" approach exists. Due to the diverse nature of plastic applications, each sector is unique and will require a different and well-thought-out combination of efforts.

Further, policy-makers need to aim for greater harmonization at the national level. The present approach to recycling in Canada (e.g., collection schemes such as EPR, fees and tax on landfilling, provincial legislation and regulation) is fragmented and can lead to confusion. A concerted approach would bring clarity to the various stakeholders.

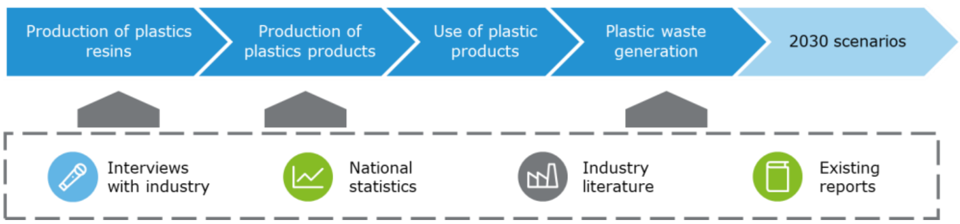
Finally, it would be beneficial to implement nation-wide monitoring of waste management and value recovery activities in order to track progress and competitiveness of the recycling industry against international benchmarks.

5. Methodology annex

5.1 Approach and scope of the study

In the absence of data covering the entire plastic value chain in Canada, a model was built to consolidate and connect the different data and information available. Figure 16 introduces the key steps of the overall approach.

Figure 16: Overall approach of the study



Source: (Deloitte, 2019a)

The resins profiled in this study (Table 13) include all key thermoplastics (plastics that can be heated, cooled and reshaped repeatedly) and thermosets (plastics that can only be shaped once due to their polymerization, which creates a three-dimensional network that cannot be remelted or solubilized).

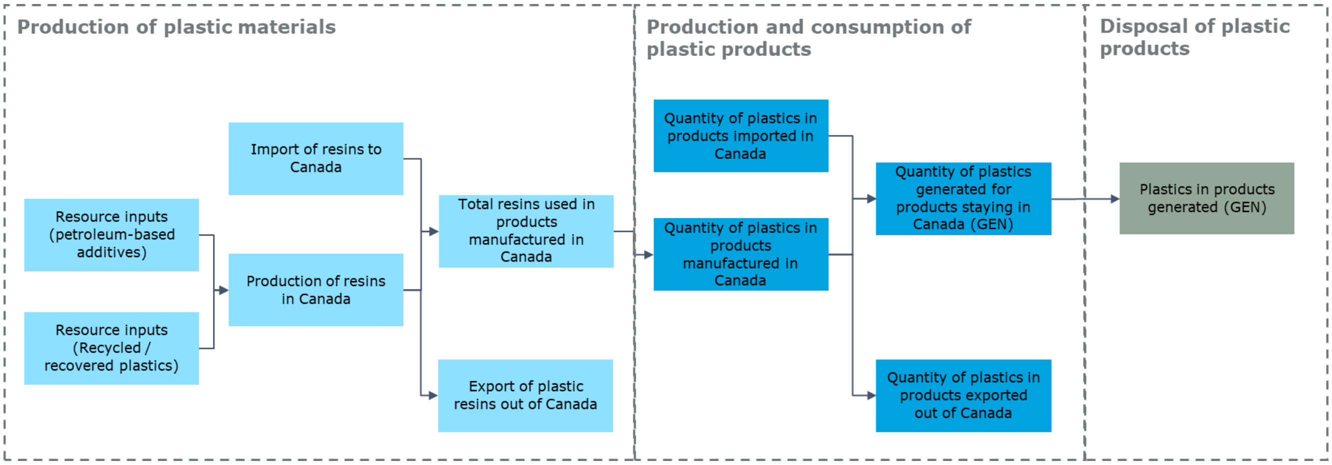
Table 13: Thermoplastic and thermosets resins profiled

Category	Resin Type	
Thermoplastics	ABS resins	Polyvinyl chloride (PVC)
	EVA copolymers	Polystyrene (PS)
	Polyamides (PA)	Polypropylene (PP)
	Polycarbonates (PC)	Polyethylene terephthalate (PET)
	Polyethylene (PE)	
Thermosets	Epoxy resins	Urea resins
	Polyurethanes (PUR)	Vinyl ester resins
	Unsaturated polyester resins	Acrylics
	Phenolic resins	

Source: (Deloitte, 2019a)

The approach taken to build the model (Figure 17) follows the plastic value chain in three phases: the production of resin and plastic materials, the production and consumption of plastic products, and plastic products' end-of-life.

Figure 17: Data flow chart of plastic products in Canada



First, a model to represent the 2016 baseline was developed, in which the various plastics products produced and traded in the Canadian economy were grouped into eight end-use sectors, defined for the purpose of this study as packaging, construction, automotive, electrical and electronic equipment, textile, white goods, agriculture and other plastics (see Section 5.3 for a description of each sector). Second, a plastic waste management model was developed to illustrate the end-of-life of plastic waste (see Section 5.3 for the detailed plastic waste management model developed for this study). Third, the models were extrapolated based on available proxies and assumptions to develop scenarios to 2030.

5.2 Sectors description

This study highlights eight sectors (also called "categories" below) that represent significant sources of plastic waste generation in Canada. Products have been grouped within those sectors based on their Supply and Use Product Classification (SUPC) code (i.e., the "MPGXXXXXX/Product Name" in the tables below).[3]

The supply and use tables include close to 500 products (i.e., unique SUPC codes). Our model considers only products related to physical goods manufactured and/or imported in Canada (SUPC codes starting with MPG). This means that other SUPC categories are excluded from our analysis, since they are not relevant in our material flow analysis (see Statistics Canada for more details on the SUPC categories[4]):

- ENExxxxxx: energy, utilities and fuels, etc.
- MPSxxxxxx: services, margins and commissions, software, etc.
- IMGxxxxxx, IMSxxxxxx: imputed codes
- FICxxxxxx: fictive materials and services, transportation margins
- NGSxxxxxx: services provided by government sector
- NNPxxxxxx: services provided by non-profit institutions serving households

[3] For more details on the SUPC codes and the concordance with other StatCan data please follow this link.
[4] For more details on the SUPC codes categories, please follow this link

In order to focus the analysis on the most material products containing plastics, a cut-off rule was applied to their plastic resin value to exclude products with a low contribution to the overall quantity of plastics generated in Canada from the analysis. The threshold chosen was CA$40 million, applied on the absolute value of the resin content in products staying in Canada. The application of this criterion was adjusted at the product level depending on various considerations, leading to the following exceptions:

- Grouping of similar products that would otherwise be excluded due to the threshold:
  - Food and non-alcoholic beverages (codes starting by MPG311 followed by 3 digits) were grouped into the MPG311XXX codes ($52 million of plastic resins staying in Canada)
- Inclusion of products that would otherwise be excluded due to the threshold, and similar to other products in existing categories and subcategories, to increase our model coverage of the economy notably for some categories and resins (polyurethane, acrylics):
  - MPG312110 / Bottled water, soft drinks and ice and MPG3121A1 / Wine and brandy were added to the Packaging – Bottles subcategory
  - MPG339905 / Signs was added to Other – Other goods
  - MPG325203 / Artificial and synthetic fibres and filaments was added to Textile
  - MPG337901 / Mattresses and foundations
- Exclusion of specific products:
  - MPG326201 / Tires, MPG326202 / Rubber and plastic hoses and belts and MPG325202 / Rubber and rubber compounds and mixtures: rubber related products were out of scope for this study
  - MPG325105 / Basic organic chemicals, n.e.c., MPG325101 / Petrochemicals, MPG3241A8 / Lubricants and other petroleum refinery products: excluded due to lack of information on the plastics used in these products
  - The cut-off rule used led to the exclusion of more than a hundred of products (codes starting with MPG), including for example:
    - MPG332500 / Builders, motor vehicle and other hardware,
    - MPG333402 / Heating and cooling equipment (except household refrigerators and freezers)
    - MPG336601 / Ships
    - MPG336900 / Other transportation equipment and related parts
    - MPG333300 / Commercial and service industry machinery
    - MPG335102 / Lighting fixtures
    - MPG334401 / Printed and integrated circuits, semiconductors and printed circuit assemblies
    - MPG336602 / Boats and personal watercraft
    - MPG333101 / Agricultural, lawn and garden machinery and equipment
    - MPG323001 / Printed products
    - MPG334A05 / Medical devicesMPG336401 / Aircraft
    - MPG336401 / Aircraft
    - MPG336403 / Aircraft parts and other aerospace equipment

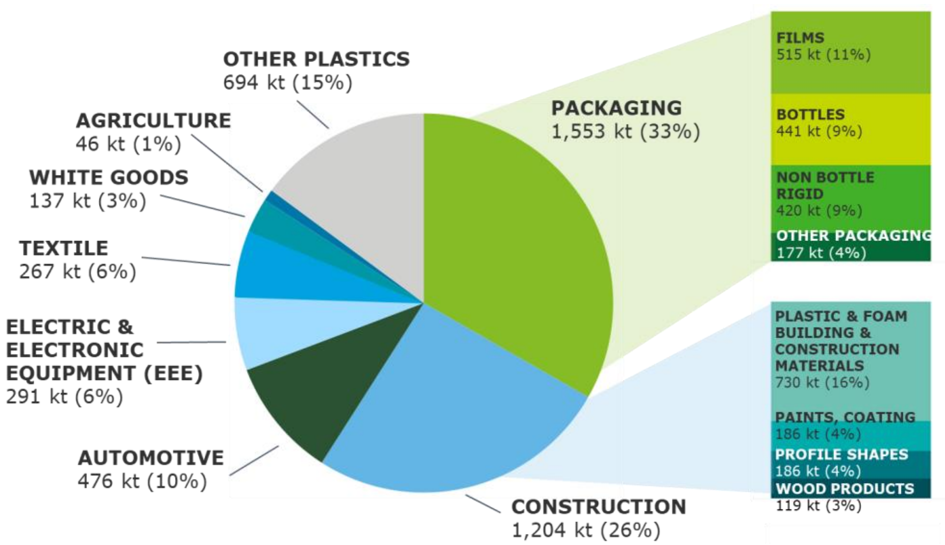
Overall, the products that were included in our model account for **88 percent of the value of plastic resins in products remaining in Canada**.

When the SUPC code was not precise enough, an additional review of Harmonized System (HS) products falling under the SUPC code was applied to assess where the code should be categorized. This additional review was conducted using HS 2017 to SUPC 2013 concordance table provided by StatCan. In very few instances, trade data related with one SUPC code was split between two customized product categories to reflect clearly distinct sector affiliation and waste management fate (e.g., MPG 335901/Batteries was split between the automotive sector for car batteries and the EEE sector for primary cells and batteries).

For some sectors, it was deemed necessary to create subcategories to provide a more granular view of key products and to reflect differences in waste management within sectors. This decision was based on information gathered on key products for each sector and their respective waste management. For example, the fate of plastic bottles was considered to be different from that of plastic films in the packaging category. Likewise, the existence of extended producer responsibility systems applicable to select products within a given sector triggered the creation of distinct sub-categories within the sector (e.g., EEE sector).

Sectors and their respective subcategories are detailed in Figure 18.

Figure 18: End-use markets for plastic products in Canada (kt, 2016)



Source: Deloitte

Packaging

Plastic packaging is commonly used to protect, preserve, store and transport products, and is the main category in terms of the end market for plastic products. It regroups films (including plastic bags), bottles and other items for sectors including food and beverage, healthcare, consumer packaged goods, and cosmetics and personal care among countless other applications.

Table 14: Main subcategories and products, category "packaging"

Category	Subcategory	Product
Packaging	Packaging – Film	MPG326102 / Plastic films and non-rigid sheets MPG326101 / Plastic bags
	Packaging – Bottles	MPG326109 / Plastic products, n.e.c. MPG326106 / Plastic bottles MPG312110 / Bottled water, soft drinks and ice MPG3121A1 / Wine and brandy
	Packaging – Non-bottle rigid	MPG326109 / Plastic products, n.e.c. MPG311XXX / Miscellaneous food products MPG325601 / Soaps and cleaning compounds MPG325400 / Pharmaceutical and medicinal products MPG325602 / Perfumes and toiletries
	Packaging – Other packaging	MPG326105 / Foam products (except for construction) MPG322209 / Other converted paper products MPG322201 / Paperboard containers MPG335901 / Batteries

Construction

Plastic has a variety of uses in the construction industry due to its strength and durability, despite being lightweight. This includes resins used in paints and coatings, profile shapes (e.g., windows and doors) and pipes, insulation board and foam, plastics used in reconstituted wood and plywood, and other generic products used in construction. Thermoplastics are often used in flooring and window covering applications. Resins and adhesives produced by this industry are used in the creation of polyvinyl chloride (PVC) pipes, flooring, insulation, roofing, windows and doors.

Note there is a large portion of plastic from the construction sector that is 'stocked' in buildings, and will likely enter waste stream more than 30 years later.

Table 15: Main subcategories and products, category "construction"

Category	Subcategory	Product
Construction	Construction – Generic	MPG326103 / Plastic and foam building and construction materials
	Construction – Paints, coatings	MPG325500 / Paints, coatings and adhesive products
	Construction – Profiles shapes & pipe fitting	MPG326104 / Plastic profile shapes MPG332A02 / Metal valves and pipe fittings
	Construction – Reconstituted wood products, plywood & veneer	MPG321203 / Reconstituted wood products MPG321201 / Veneer and plywood MPG321202 / Wood trusses and engineered wood members

Automotive

Plastic in the automotive sector accounts for between 8 and 10 percent of the vehicle weight and is constantly increasing as automobile manufacturers are replacing steel and aluminum parts with plastic parts that help to make automobiles lighter and more fuel efficient. Motor vehicle manufacturers typically use plastic and resin inputs in the creation of automotive parts (e.g., bumper, tanks and fluid containers) and interior components (e.g., seats, dashboard).

Table 16: Main subcategories and products, category "automotive"

Category	Subcategory	Product
Automotive	Vehicles – Generic	MPG326107 / Motor vehicle plastic parts
		MPG336360 / Motor vehicle interior trim, seats and seat parts
		MPG336390 / Other miscellaneous motor vehicle parts
		MPG336370 / Motor vehicle metal stamping
		MPG336320 / Motor vehicle electrical and electronic equipment and instruments
		MPG336120 / Medium and heavy-duty trucks and chassis
		MPG336330 / Motor vehicle steering and suspension components
		MPG336350 / Motor vehicle transmission and power train parts
		MPG336111 / Passenger cars
		MPG336112 / Light-duty trucks, vans and sport utility vehicles (SUVs)
		MPG335901 / Batteries

Electric and electronic equipment (EEE)

Plastics in the Electric and electronic equipment (EEE) sector include two subcategories:

- Products such as computers, phones, printers, and audio-video devices were grouped into an "Electronic Products Recycling Association" (EPRA[5]) subcategory as they are most likely targeted by an EPR scheme in Canada.
- Products such as electric wire, cables and other components were grouped into a "generic" subcategory and are most likely not covered by an EPR scheme in Canada.

Table 17: Main subcategories and products, category "EEE"

Category	Subcategory	Product
EEE	EEE – EPRA	MPG335903 / Wiring devices
		MPG334201 / Telephone apparatus
		MPG334100 / Computers, computer peripherals and parts
		MPG334209 / Other communications equipment
	EEE – Generic	MPG335902 / Communication and electric wire and cable
		MPG335909 / Other electrical equipment and components

[5] For more information, please visit EPRA website.

Textile

The plastic from textiles is comprised of artificial fibres such as polyester and nylon. The category also includes textiles for furniture, and fibres from carpets, rugs and mats.

Table 18: Main subcategories and products, category "textile"

Category	Subcategory	Product
Textile	Textile – Generic	MPG31B001 / Men's, women's, boys' and girls' clothing
		MPG31A002 / Fabrics
		MPG31A004 / Other textile furnishings
		MPG31A005 / Textile products, n.e.c.
		MPG31A003 / Carpets, rugs and mats
		MPG31B005 / Footwear
		MPG325203 / Artificial and synthetic fibres and filaments

White goods

The white goods sector refers to large appliances such as fridges and stoves, as well as small household appliances such as food processors and electric kettles.

Table 19: Main subcategories and products, category "white goods"

Category	Subcategory	Product
White goods	White goods – Generic	MPG335204 / Major appliances
		MPG335203 / Small electric appliances

Agriculture

The agricultural sector accounts for the plastic used for the transportation of grains and seeds, fertilizer and pesticide packaging, and agricultural films. Due to the lack of a specific category focusing on agricultural plastics, the model used a portion of the plastic films and non-rigid sheets category. This portion was estimated based on the amount of agricultural plastic waste generated in Canada (CleanFarms estimate) extrapolated to obtain the quantity of agricultural plastic products staying in Canada.

Table 20: Main subcategories and products, category "agriculture"

Category	Subcategory	Product
Agriculture	Agriculture – Generic	MPG326102 / Plastic films and non-rigid sheets

Other plastics

The "other plastics" sector aggregates the diversity of product categories that could not be categorized elsewhere. This heterogeneous category includes plastics such as chemical products and resins, plastics used in medical, dental and personal care, toys, household furniture, sporting goods, mattresses, and industrial machinery.

Table 21: Main subcategories and products, category "other plastics"

Category	Subcategory	Product
Other	Other – Miscellaneous chemical, resins, organic chemicals, petrochemicals	MPG325900 / Chemical products, n.e.c. MPG325201 / Plastic resins
	Other – Other goods	MPG339100 / Medical, dental and personal safety supplies, instruments and equipment MPG339909 / Other miscellaneous manufactured products MPG339903 / Toys and games MPG337102 / Household furniture MPG339902 / Sporting and athletic goods MPG339901 / Jewellery and silverware MPG327A02 / Glass (including automotive), glass products and glass containers MPG339905 / Signs MPG337901 / Mattresses and foundations
	Other – Machinery	MPG333200 / Other industry-specific machinery MPG333102 / Logging, mining and construction machinery and equipment MPG333909 / Other miscellaneous general-purpose machinery

Table 22 provides an overview of the main products containing plastics included in the categories or "sectors" developed for this study.

Table 22: Description of sectors for end-market products containing plastic

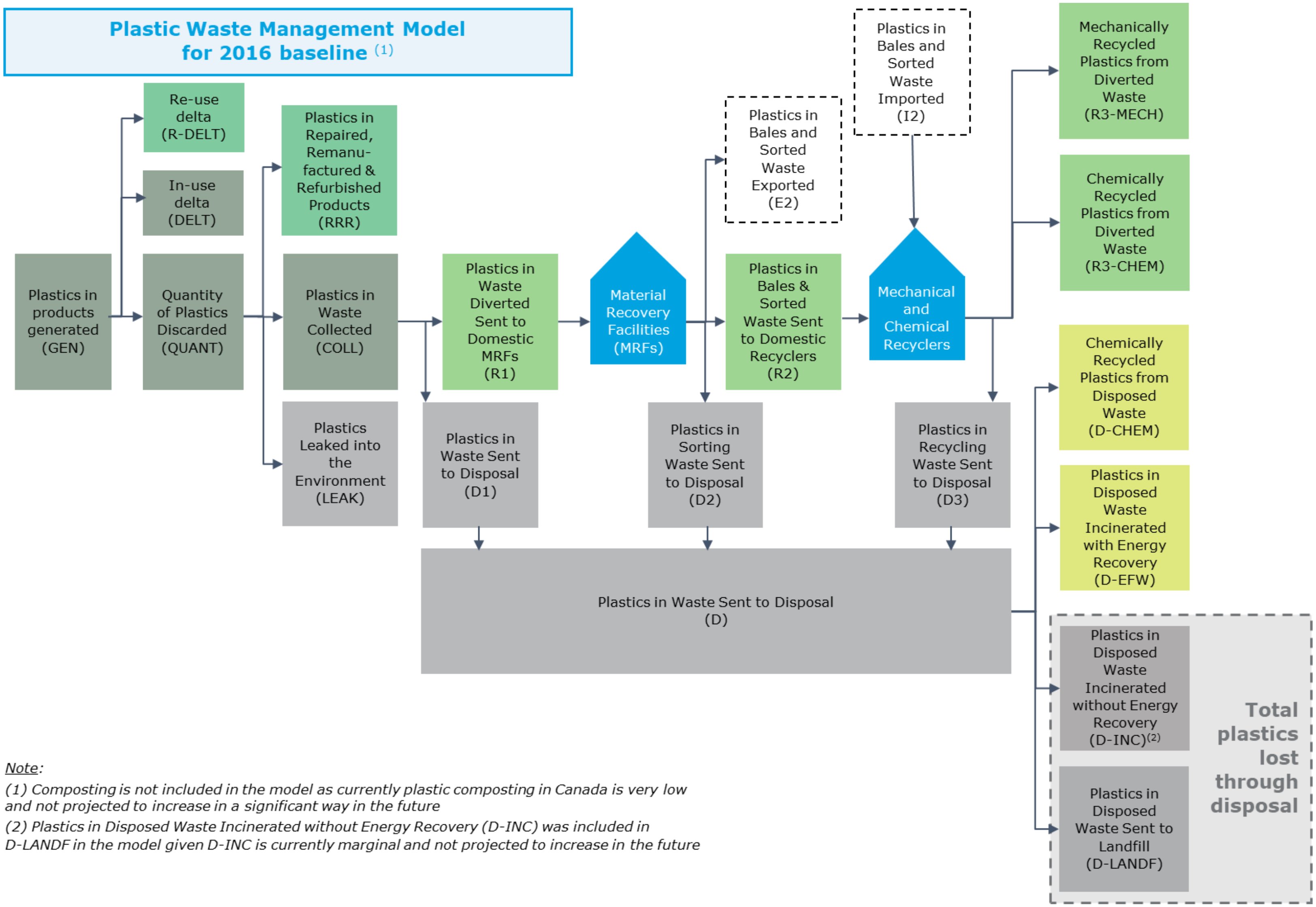
Sector	Type of plastic products
Packaging	Includes films (e.g., plastic bags), bottles and other items, for sectors such as food and beverage, healthcare, consumer packaged goods, and cosmetics and personal care.
Construction	Includes resins used in paints and coatings, profile shapes (e.g., windows and doors) and pipes, insulation board and foam, plastics used in reconstituted wood and plywood, and other generic products used in construction.
Automotive	Comprises plastic parts such as the bumper, tanks and fluid containers, and the plastic components inside the passenger compartment, seats and dashboard.
Electric and electronic equipment (EEE)	Parts in electronics such as computers, phones, printers, audio-video devices, and items such as electric wire, cables and other components.
Textile	Artificial fibres such as polyester and nylon. Also includes textile for furniture, and fibres from carpets, rugs and mats.
White goods	Plastic contained in large appliances such as fridges and stoves, and small household appliances including food processors and electric kettles.

Sector	Type of plastic products
Agriculture	Plastic used for grains and seeds transportation, fertilizer and pesticide packaging, and agricultural films.
Other plastics	This heterogeneous category includes plastics such as chemical products and resins, plastics used in medical, dental and personal care, toys, household furniture, sporting goods, mattresses, and industrial machinery.

5.3 Description of the plastic waste management model

Figure 19 presents a flow chart of the lifecycle of plastic waste in Canada, as modelled in this study, while Table 23 defines the terms used.

Figure 19: Flow chart of plastic waste in Canada



Note:
(1) Composting is not included in the model as currently plastic composting in Canada is very low and not projected to increase in a significant way in the future
(2) Plastics in Disposed Waste Incinerated without Energy Recovery (D-INC) was included in D-LANDF in the model given D-INC is currently marginal and not projected to increase in the future

Table 23: Legend of terms used in the flow chart of plastic waste in Canada

Acronym	Definition	Key assumptions and hypothesis	Reference
GEN	Quantity of plastics in products generated in Canada.	Approach taken to build this model leveraged StatCan's Supply and Use Tables (SUT) to assess the generation (i.e., arrival on the Canadian market) of products containing plastic. There are two main sources for those products: domestically manufactured products using plastic resins and net imports of finished or semi-finished goods containing plastic.	(Deloitte, 2019a)
DELT	The in-use delta measures the difference between the plastic products generation for a product category in a given year and the estimated plastic waste generation of that same product category for the same year, before taking into account any additional re-use (see R-DELT below).	The in-use delta is based on the average product category lifetime, the past annual sector market growth during that product category lifetime, and the evolution of the average plastic content in that product category over its lifetime. The in-use delta impacts the automotive, construction and EEE sectors the most, due to relatively long product lifetimes.	(Deloitte, 2019a)
R-DELT	Direct re-use is a way to extend the expected end-of-use of products by a certain amount of time. As such, the re-use delta models the fact that a reused product enters the waste stream later than an average non-reused product.	The re-use delta is modelled in a similar way to the in-use delta (DELT). Its calculation is based on an average additional product lifetime of 50 percent, the past annual sector market growth during that lifetime, and an estimation of the applicable re-use rate within each sector.	(Deloitte, 2019a)
QUANT	Quantity of plastics discarded represents the plastic entering waste streams.	It is equal to the quantity of plastics in product generated in Canada (GEN) minus the in-use and re-use deltas.	(Deloitte, 2019a)
RRR	Plastics in repaired, remanufactured and refurbished products (RRR). Remanufacturing and comprehensive refurbishment take place within industrial or factory settings and result in quasi-new products, with a full-service life identical to a new product, for which production is avoided.	Currently, it is not certain that RRR activities occur on a large scale in Canada for products containing plastics. Accordingly, RRR is not quantified in the 2016 baseline model. However, RRR is considered in 2030 scenarios of the Task 2 report, in which they have a direct impact on plastic waste diversion.	(Deloitte, 2019a) and (Deloitte, 2019b)

Acronym	Definition	Key assumptions and hypothesis	Reference
LEAK	Plastics leaked permanently into the environment,	Litter can be split into fractions, the first of which is temporary and eventually captured by municipal waste collection (e.g. when cleaning streets and parks). In the model, this fraction is included in the plastics in waste sent to disposal (D1). The second fraction of plastics littered is never collected and considered to be permanently lost into the environment. This second fraction, also called plastics leaked into the environment (LEAK) is estimated in the model. Global estimates of plastic leakage into the environment were prepared by Jambeck et al. in 2015. In this study, the authors estimated that approximately 10,000 tonnes of plastic waste were mismanaged in coastal areas and nearly 29,000 tonnes across Canada.	(Deloitte, 2019a)
COLL	Plastics in waste collected, which are either sent to a sorting facility (R1) or to disposal (D1).	Plastics in waste collected is equal to the after-use quantity (QUANT) minus the plastic leaked into the environment (LEAK) and plastics in repaired, remanufactured and refurbished products (RRR). It is also equal to R1 + D1.	(Deloitte, 2019a)
R1	Plastics in waste diverted and sent to domestic MRFs.	It is calculated using a diversion rate based on information gathered in the Task 3 report and additional references. R1 = R2 + D2 + E2	(Deloitte, 2019a)
D1	Plastics in waste sent to disposal.	It is calculated based on the current rates presented by StatCan and research from Cheminfo	(Deloitte, 2019a)
R2	Plastics in bales and sorted waste sent to domestic recyclers.	Calculated based on the sector-specific sorting yield (R2/R1). Yields were sourced from studies such as MORE (packaging), Ontario Electronic Stewardship (EEE), or estimations relying on literature reviews and benchmarks. Another equation involving R2 is: I2 + R2 = R3 + D3	(Deloitte, 2019a)
D2	Plastics in waste sent to disposal by MRFs. Represents the fraction rejected by the sorting facilities.	D2 is deducted using R1 and R2, given that we have D2 = R1 – R2 – E2. However, as E2 was not quantified in the model, we have D2 = R1 – R2.	(Deloitte, 2019a)
E2	Plastics in bales and sorted waste exported.	Documented in Task 3 report but not quantified in the model as some information was missing on a resin by resin basis.	(Deloitte, 2019c)
I2	Plastics in bales and sorted waste imported.	Documented in Task 3 report but not quantified in the model as some information was missing on a resin by resin basis.	(Deloitte, 2019c)

Acronym	Definition	Key assumptions and hypothesis	Reference
R3	Recycled plastic from diverted waste.	Based on the reprocessing yield (R3/R2), which refers to the efficiency of recycling operations. It is a combination of chemical and recycling yields. With the exception of EEE waste, for which recycling efficiency was available, reprocessing yields were assessed at the resin level and derived from current recycling operations or sourced from other comparable jurisdictions (e.g., Europe) when no Canadian data was available. It is also equal to R3 MECH+ R3 CHEM	(Deloitte, 2019a)
R3-MECH	Mechanically recycled plastic from diverted waste.	Stemming from the diverted waste stream, these plastics are mechanically reprocessed into flakes or pellets, ready for incorporation as recycled resins by plastic products manufacturers or resin compounders. This currently represents the dominant output of municipal recycling programs across the country.	(Deloitte, 2019a)
R3-CHEM	Chemically recycled plastic from diverted waste.	Stemming from the diverted waste stream, these plastics are chemically converted into shorter molecules, ready to be used to produce new plastics or fuels. Given low contamination levels of input material, chemical recycling from diverted waste usually attempts to convert most of the received feedstock into the monomer state of the original polymer resin, in order to generate the highest possible revenue. By-products are usually other chemicals or fuels.	(Deloitte, 2019c)
D3	Plastics in recycling waste sent to disposal; represents the fraction rejected by the recyclers.	Based on the reprocessing yield.	(Deloitte, 2019a)
D	Total plastics in waste sent to disposal	Some recovery can still occur whether through chemical recycling (D-CHEM) or incineration with energy recovery (D-EFW). The rest is either incinerated without energy recovery (D-INC) or landfilled (D-LANDF). D = D1 + D2 + D3.	(Deloitte, 2019a)
D-CHEM	Chemically recycled plastic from disposed waste.	Stemming from the disposed waste stream, mainly from municipal solid waste (MSW), these plastics are chemically converted into fuels such as methanol, ethanol, diesel, and other related chemicals. Given the relatively high contamination level of the input material, chemical recycling from disposed waste does not usually directly return to monomers as R3-CHEM sometimes does.	(Deloitte, 2019c)
D-EFW	Plastics in disposed waste incinerated with energy recovery.	Also called thermal recovery, this stream accounted for the vast majority of thermal treatment of plastics in Canada with 134.5kt in 2016 (the other avenue being incineration without energy recovery). Most facilities use an energy recovery approach as plastics have relatively high caloric values relative to other waste materials and relative to some conventional fuels (e.g., PE, PP and PS have energy content 50 percent higher than coal). Most of the current treatment capacity originates from five waste-to-energy facilities, one treatment centre, and (to a lesser extent) cement plants.	(Deloitte, 2019c)

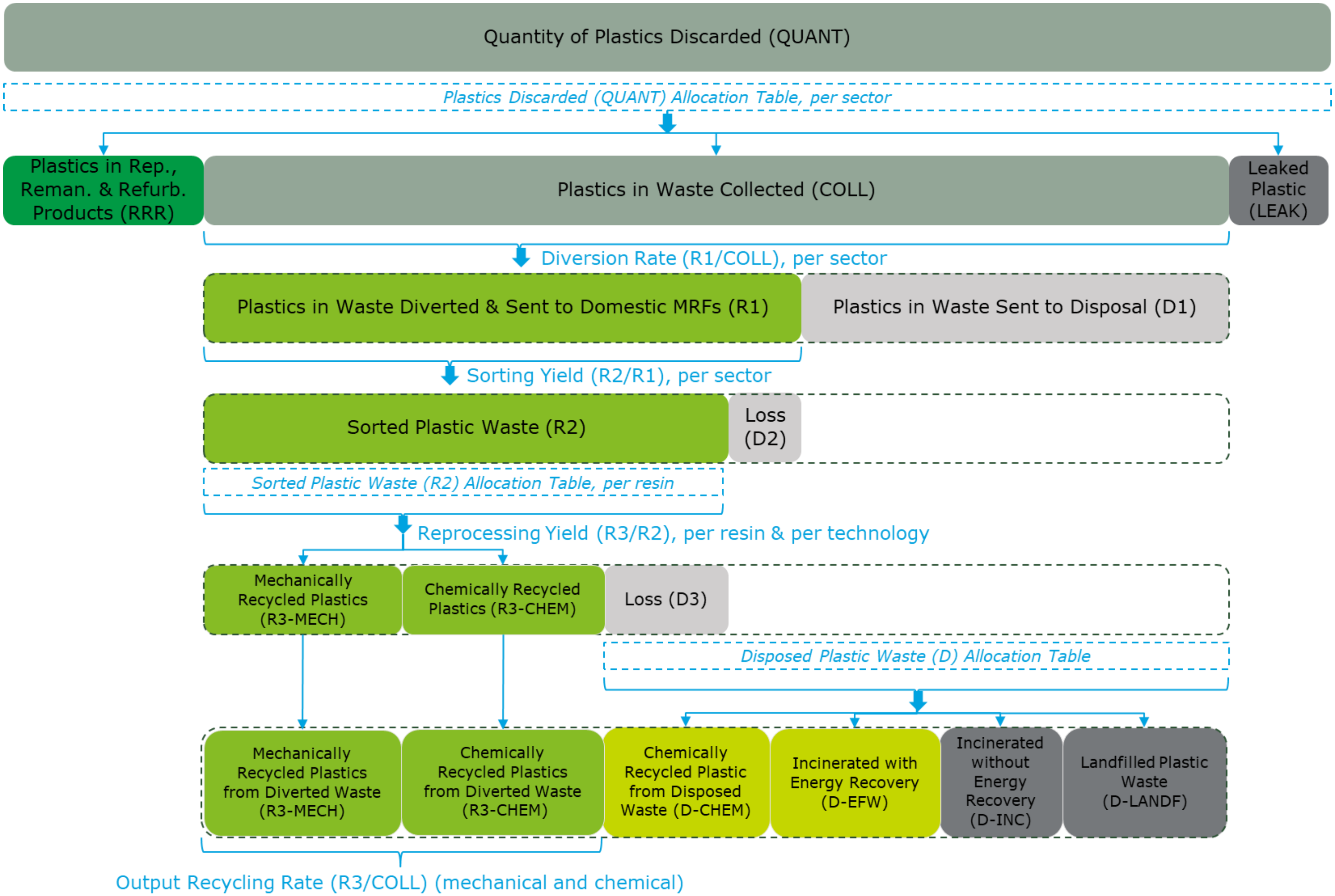
Acronym	Definition	Key assumptions and hypothesis	Reference
D-INC	Plastics in disposed waste incinerated without energy recovery.	Incineration without energy recovery accounted for less than two percent of thermal treatment for plastics in 2016. Only one site in Canada (Lévis, built in 1976) is known to incinerate municipal solid waste without energy recovery. Given the small amount, D-INC values have not been singled out in the model and were rather included in D-EFW.	(Deloitte, 2019c)
D-LANDF	Plastics in disposed waste sent to landfill	Based on the material flow model. The amount landfilled is the difference between after-use quantities (QUANT) and each of the above life cycle stages. StatCan's information on disposal in Canada was also used as a benchmark and data validation source.	(Deloitte, 2019a)

The study has also defined some rates and yields for clear recognition of the performance level presented in the study. These are presented in Table 24 and illustrated in Figure 20.

Table 24: Acronyms of rates and yields used in the waste management model

Acronym	Definition
R1/COLL	Diversion rate, or the share of plastic diverted from direct disposal and sent to a sorting facility, divided by COLL. This rate is assessed by sector.
R2/COLL	Output sorting rate, or the share of plastic sorted by sorting facilities and sent to a reprocessing facility, divided by COLL. This rate is assessed by sector.
R3/COLL	Output recycling rate, or the share of plastic that is ultimately reprocessed, whether through chemical or mechanical recycling from diverted waste, divided by COLL. This rate does not include D-CHEM.
(R3+D-CHEM+ D-EFW)/COLL	Value recovery rate, or the share of plastic that is ultimately value recovered whether through chemical or mechanical recycling from diverted and disposed waste or through thermal recovery, divided by COLL.
R2/R1	Sorting yield, or the amount of plastics MRFs were able to sort out and send to reprocessing facilities, divided by the total amount of unsorted plastic received. This yield is affected by factors including the quality of input waste material, contamination, type of plastics received, and sorting technologies and equipment. It illustrates the efficiency of sorting operations, and is assessed by waste stream category or sector.
R3/R2	Reprocessing yield, or the amount of recycled materials (e.g., flakes or pellets of recycled resins, monomers) reprocessing facilities were able to produce and send to end-users, divided by the total amount of sorted plastics waste received from MRFs. It illustrates the recycling efficiency of reprocessing operations, and is assessed by resin and technology (chemical or mechanical).

Figure 20: Key steps of the waste management model



5.4 Key assumptions and limitations

Considering the range of resins included in this study (both thermoplastics and thermosets), the scope of this study is wider than most other studies conducted on plastic in other jurisdictions, which tend to focus on specific sectors (packaging in particular) and are usually limited to (a selection of) thermoplastics only. This has an influence on the calculated rates and yields presented in this study and should be considered when comparing performance between jurisdictions.

6. Bibliography

Deloitte. (2019a). *Economic study of the Canadian plastic industry, markets and waste- Task 1.* Government of Canada, Environment and Climate Change Canada Internal Report.

Deloitte. (2019b). *Economic study of the Canadian plastic industry, markets and waste-Task 2.* Government of Canada, Environment and Climate Change Canada Internal Report.

Deloitte. (2019c). *Economic study of the Canadian plastic industry, markets and waste-Task 3.* Government of Canada, Environment and Climate Change Canada Internal Report.

Deloitte. (2019d). *Economic study of the Canadian plastic industry, markets and waste-Task 4.* Government of Canada, Environment and Climate Change Canada Internal Report.

More Recycling. (2018). *2016 Post-Consumer Plastics Recycling in Canada.*