BACKGROUND MATERIALS FOR CIRCULAR ECONOMY SECTORAL ROADMAPS

PLASTICS

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Smart Prosperity Institute

About Smart Prosperity Institute

Smart Prosperity Institute is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.
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Any errors or omissions remain the sole responsibility of the authors.

ABOUT THE CIRCULAR ECONOMY GLOBAL SECTOR BEST PRACTICES

This publication series aims to provide a starting point in the journey towards a circular economy. These materials are intended to be used as a background resource and rich reference source for future efforts to engage Canadian firms and innovators in this transition, and to build sector-based roadmaps to a circular economy in Canada.

Twelve core strategies for *rethinking* resource consumption and *optimizing* the use of resources to transition to a circular economy are detailed in the Introduction to the series. Real-world practices supporting these strategies are being catalogued for seven sectors, each profiled in its own document:

1. Minerals and Metals
2. Electronics
3. Agri-food
4. Construction
5. Plastics
6. Bio-economy
7. Automotive

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PLASTICS

5.1. Introduction to Plastics

The *Circular Economy Global Sector Best Practices* series aims to provide a starting point, background resource, and rich reference source for future efforts to engage Canadian firms and innovators in the journey towards a circular economy, and to build sector-based roadmaps to a circular economy in Canada.

This report profiles the plastics sector. It begins with an outline of the economic and environmental importance of the sector, including data on economic potential of waste resources where available. It then profiles the existing circular practices that were identified in the sector, organized according to a common framework for circular economy approaches and strategies developed in 2018 by L'Institut EDDEC in collaboration with RECYC-QUÉBEC, and described in the Introduction to the series. This profile begins with a high-level summary of the circular practices found in each sector, and snapshots of these practices in application, and then moves on to list applied, real world examples for each of these strategies and practices. It provides a list of additional resources for researchers, practitioners, and policy-makers, as well as selected global public policies, and an annotated bibliography of key reports specific to circularity for construction.

5.2. Background

Over the past half-century, plastics production has boomed at the global level, rising from 15 million tonnes in 1964 to 311 million tonnes in 2014.[1] It is expected to double over the next two decades.[2] Virgin fossil fuels constitute 90% of plastic feedstock, representing 6% of global oil consumption (comparable to the annual oil consumption of the global aviation sector)[3] and are expected to account for 20% of oil consumption by 2050, if the current growth in plastic use continues.[4] By 2050, the world's plastic use could consume 15% of the global annual carbon budget of a 2°C world.[5]

Marine plastics damage ecosystems and the economic activities that depend on them. The oceans contain over 150 million tonnes of plastics, mostly from plastic packaging, in the form of either microscopic particles or as parts or wholes of recognizable products.[6] Annually, 8 million tonnes of plastic leaks into the ocean, an amount expected to double by 2030 and quadruple by 2050.[7] If nothing changes, the ocean will contain one tonne of plastic for every three tonnes of fish by 2025, and more plastics than fish by weight by 2050.[8] The issue of microplastics in aquatic environments is particularly insidious as it can be difficult to arrest their introduction to waterways, and microplastics are now found in municipal drinking water all around the planet.[9]

In Canada, an estimated 10,000 metric tonnes of plastic enter the Great Lakes annually,[10] and one percent of plastic waste leaked into the environment in 2016. A Canadian Plastics Science Agenda was launched in 2019 to detect, quantify, and characterize plastics in the environment, and increase understanding of the impacts of plastics on wildlife, human health, and the environment, among other goals.[11]

Countries around the world, Canada included, are mobilizing to prevent plastic release into the environment by reducing plastic use and waste, increasing reuse, and value recovery through recycling. These efforts are engaging a wide range of sectors. Governments, businesses up and down the plastics value chain, NGOs, and consumers are collaborating to rethink the way plastics are designed, used, and reused across the economy.

Globally, plastic packaging, most of which is single-use, accounts for 26% of the total volume of plastics used,[12] and 47% of plastic waste streams.[13] Externalities, including the greenhouse gas emissions from production, amount to an estimated C$52 billion annually, exceeding the global plastic packaging industry's profits.[14] An estimated C$107-160 billion, amounting to 95% of plastic packaging's material value, disappears from the economy after one short use.[15] 32% of plastic packaging waste leaks from collection systems, threatening infrastructure and natural ecosystems.[16] Only 14% of plastic packaging is collected for recycling, much lower than the global recycling rates for paper, iron, and steel.[17] Of the packaging waste collected, only 5% of its material value is recovered for further use.[18] A circular model for plastic packaging could create C$921 billion in value for the global economy.[19]

In Canada, virgin plastic resin production is concentrated in Ontario and Alberta, with sales of C$10.1 billion CAD in 2017, while recycled resin sales were valued at C$350 million in 2016.[20] Virgin plastic resin is highly trade exposed, with 77% exported and imports fulfilling 71% of domestic demand.[21] The United States accounts for 80% of Canadian plastics imports and exports.[22] Most plastic demand in Canada (93%) is fuelled by companies using plastic products as components for final products, and few products containing plastics are designed with their Canadian end-use in mind.[23]

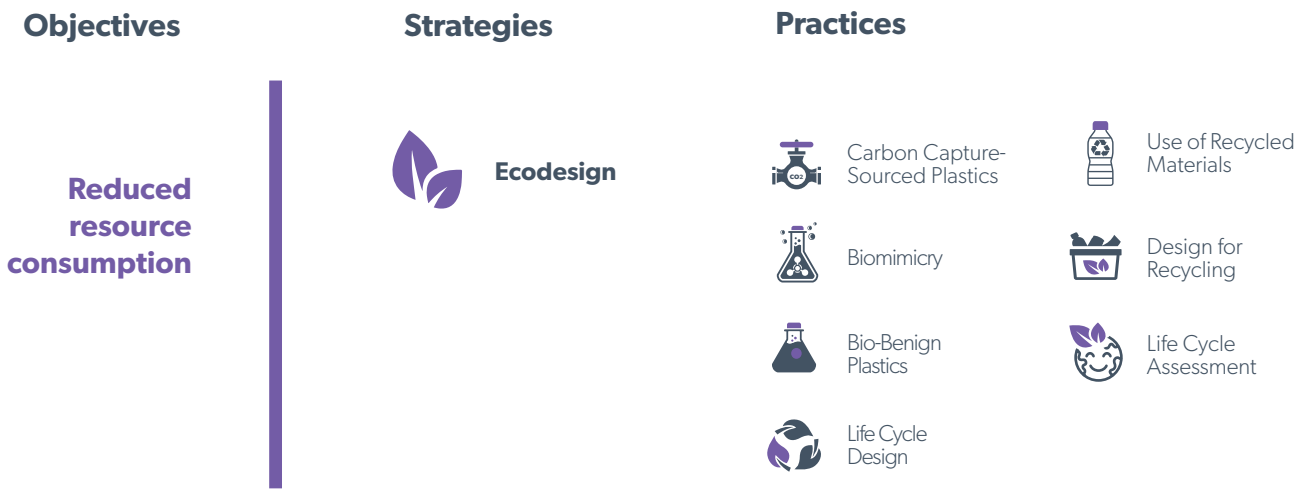
Canada's plastics economy remains mostly linear. An estimated 86% of plastic waste was landfilled in 2016, another 4% was incinerated with energy recovery, and only 9% was recycled.[24] Packaging (43%), automotive (9%), textiles (7%), and electrical and electronic equipment (7%) are the sectors that generate the most plastic waste within Canada.[25] Although the construction sector creates only 5% of plastic waste in Canada, it consumes 26% of plastics on the market;[26] the plastic that is currently "stocked" in buildings could become a more significant source of plastic waste when rebuilding occurs in the future.[27]

Based on the 2016 value of virgin plastic resin, Canada's plastic waste represented a lost economic opportunity of C$7.8 billion.[28] A circular economy for plastics in Canada, in which 90% of plastic waste were recovered, would result in C$500 million annual costs avoided, 42 000 new direct and indirect jobs, and annual greenhouse gas emissions reductions of 1.8 megatonnes of CO_2 equivalent by 2030.[29] The far-reaching changes needed to achieve this scenario depends, however, on intensive efforts by stakeholders across the public and private sectors.[30]

5.3. Overview of Circular Economy Practices in the Plastics Sector

Companies manufacturing and using plastics have begun to invest in the research and implementation of circular solutions. These investments are being made to help address the sector's greatest challenges, such as ever-increasing demand for virgin plastics and strong consumer concern about plastic waste and marine pollution. Figure 5-1 summarizes the specific practices employed in the plastics sector, organized according to the four objectives for a circular economy and twelve core supporting strategies described in the Introduction to this publication series. Some of these are highlighted below. This is followed by a listing of applied examples of these strategies and practices, with hyperlinks to additional information. Canadian examples are denoted by a red superscript (CDN).

Figure 5-1. Circular economy objectives, strategies, and practices found in the plastics sector



Intensified product use

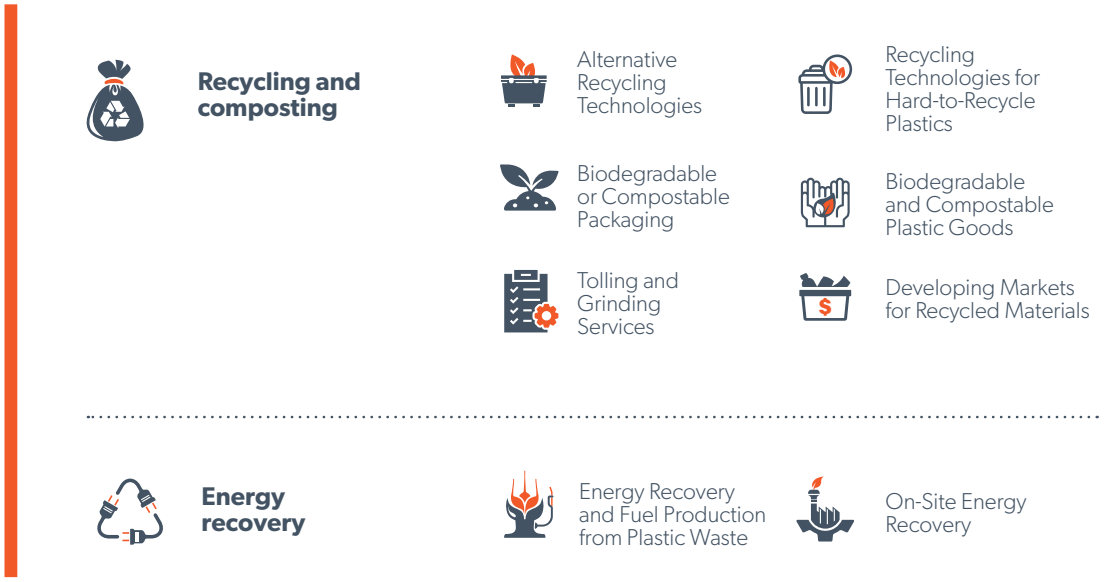
- **Process optimization**
  - Closed Loop Manufacturing
  - Energy Efficient Production
- **Responsible consumption and procurement**
  - Content Labelling
  - Reduced Single-Use Plastics
  - Reduced Packaging
  - Sustainable Purchasing
- **Sharing economy**
  - Innovation Hubs
- **Short-term renting**
  - Reusable Packaging Services

Extending life of products and components

- **Maintenance and repair**
  - Durable Goods Recycling
  - Self-Healing Plastics
- **Donating and reselling**
  - Materials Matchmaking Platforms
- **Refurbishing**
  - Plastics Repair
- **Performance economy**
  - None found

Giving resources new life

- **Industrial ecology**
  - Reduced Supply Chain Leakage
  - Vertical Integration
  - Integration of Small-Scale Recyclers



Objectives, Strategies, and Practices

The plastics sector has many examples of promising circular practices, but many are still niche applications. **Ecodesign** is a key strategy for **REDUCED** resource consumption in the plastics sector. One promising approach is researching plastics made from carbon resources gathered using carbon capture technology, thus reducing carbon stores in the atmosphere while simultaneously reducing the need to exploit fossil fuel resources for producing plastic. Other examples of ecodesign practices include integrating recycled resins with virgin resins in plastic production, discontinuing the use of plastics that cannot be recycled, or designing their packaging with modularity in mind. Producers of plastics can also reduce resource consumption through **closed loop manufacturing practices**, for example through the use of polymers that can be infinitely repurposed. Consumers also play an important role in reducing resource consumption from plastics, by **responsible consumption and procurement** initiatives such as pressing grocery chains to phase out plastic bags or fast-food chains to eliminate unrecyclable plastic in their containers.

Other practices in this sector look to **OPTIMIZE** resource use through **intensified use of products**. The Plastic Waste Innovation Hub, for example, is a platform where knowledge on how to eliminate plastic waste is freely shared amongst participants from varying fields, including science, engineering, and design. Packaging can be reused through **reusable packaging** platforms, such as TerraCycle's Loop delivery systems, which partners with corporations such as Unilever, Procter & Gamble, and Nestlé, or through reusable shipping pallets.

Extending the life of products and their components is another strategy to **OPTIMIZE** resource use. Plastic products can be **maintained and repaired**, for example a self-healing plastic being developed at the University of Illinois. This product repairs itself at room temperature, can be produced at a low cost, and uses technology that is potentially scalable.

Loop Industries: Recycling low-value plastic waste

Loop Industries is a Québec-based company creating recycling opportunities for low-value plastic waste. Working with plastics that can be difficult to recycle, including plastic packaging, carpets, textiles, and ocean-degraded plastics, Loop Industries depolymerizes this plastic waste down to its base building blocks. These are then filtered, purified, and repolymerized to create a virgin PET resin suitable for food grade packaging. This circularization of the plastic has a lesser life cycle environmental impact compared to the creation of plastics from fossil fuels: 63% less global warming impact, 79% less impact on ozone depletion, 88% less impact on smog, and 80% lower non-renewable energy demand. Loop Industries has attracted international attention, with supply chain agreements with Coca-Cola, Danone, PepsiCO, and L'OCCITANE, among others, pioneering an environmentally-based movement towards the recovery of plastic waste for reuse that ensures plastics can be sustainably used into the future.[32,33]

Donating and reselling used materials represents another avenue to extend the life of products. Online marketplaces like the Excess Materials Exchange match used plastics with their highest-value reuse opportunity. **Refurbishment** is yet another method to extend the life of plastics, and some plastics can be purposefully designed to be durable and repairable. Companies such as First Place Plastics Welding repair thermoplastics from a variety of sources.

Finally, there are a number of ways that plastics can be given **new life as a resource**. **Industrial ecology** models include vertical integration, such as Ikea's purchase of a stake in a Dutch plastics recycling firm in order to better secure their long-term supply of recycled plastics. Technologies exist to integrate small-scale recyclers and combine the plastic waste from multiple sources, such as from informal last-mile recyclers. Novel plastic polymers have been developed using high-quality plastic from sources, like computers and other household electronics and appliances, to create a durable plastic from **recycled sources**. There have been significant innovations in **recycling technologies** for plastics that have previously been difficult to recycle, including new enzymes that can break down plastics into their original monomers, which can then be reconstructed, perhaps infinitely, into high-quality materials. **Extended producer responsibility** can encourage recycling and reduce the amount of waste sent to landfills. Encorp Pacific operates the extended producer responsibility program on behalf of the beverage and retail industry in the province of British Columbia, and recovered 71% of plastic beverage containers in 2018. **Biodegradable** plastics, primarily used for packaging, can be decomposed in certain conditions. It should be noted, however, that some so-called biodegradable plastics are not able to biodegrade in many traditional composting facilities or in natural environments, though this may change with further technological development.[31] Lastly, **energy recovery** from plastics converts mixed plastic waste into various petrochemicals that could then be potentially used as fuels, or incinerates it directly. **On-site energy recovery systems** can be used by municipalities, hospitals, campuses, and other institutions to convert most forms of waste, including municipal solid waste and industrial waste, into syngas. However, energy recovery is the lowest tier of the waste management hierarchy, hence plastics should only be used for fuel if they cannot be put to higher use through reuse or recycling.

TerraCycle's Loop : An online platform for zero waste shopping

TerraCycle is a New Jersey social enterprise founded to eliminate waste. In concert with corporations such as Procter & Gamble and Nestlé, TerraCycle developed Loop, an online platform for zero waste shopping that replaces single-use packaging with reusable packaging. With the participation of well-known brands including Haagen-Dazs, Pantene, and Tide, Loop offers customers the option of receiving their goods in reusable containers. This transfers the responsibility for containers from the consumer to the producers, who must ensure that their packaging is of sufficient quality to be reused multiple times. Loop's delivery system dispatches goods through UPS along with other deliveries to lower emissions. They calculate that after five uses of the Loop system, environmental impacts, as measured by global warming potential over the next 100 years in terms of kg of CO2-equivalent units, are reduced by 50% compared to using products with single-use containers. The success of the Loop program through their online platform has prompted TerraCycle to expand this program to brick-and-mortar stores, expanding the reach of reusable packaging for consumer goods. [34]

Specific Examples: Objective 1, Reduced Resource Consumption

Ecodesign

Carbon Capture-Sourced Plastics

- Carbon Engineering[35] CDN has created a process that combines renewable hydrogen with carbon dioxide captured directly from the atmosphere to produces hydrocarbons like ethanol and methanol, which can be used to create plastics.
- Newlight[36] has developed a process that uses water, minerals, microorganisms, and renewably-sourced greenhouse gases like methane or carbon to create an ocean-degradable material that can be used to create fibers or solid parts.
- The University of Toronto[37] CDN is researching an alternative method for creating plastics from captured carbon using an electrolyzer to reduce the process's energy requirements.

Biomimicry

- Wyss Institute for Biologically Inspired Engineering[38] researchers invented Shrilk, a rapidly biodegradable bioplastic derived from discarded shrimp shells and silk protein. The material has potential for use in medical applications.

Bio-benign plastics

- Aquapak[39] produces Hydropol™, a non-toxic polymer that can be turned into a blown film or added to fossil fuel-based plastics, bio-based plastics, or paper.
- Nestlé[40] has partnered with Daimler Scientific to develop plastic bottles made from the PHA polymer Nodax™, which researchers have found to degrade in soil, fresh water, and sea water.

Life cycle design

- Mondi[41, 42] collaborated with Werner & Mertz to create StripPouch, a recyclable mono-material stand-up pouch for laundry detergent, designed using Cradle to Cradle® principles. The pouch is 100% recyclable in mechanical recycling systems.
- NewGen Surgical[43] takes into account materials, packaging, end-of-life, performance, supply chain considerations in the development of its plant-based, biodegradable surgical products.

Use of recycled materials

- Coca-Cola[44] aims for its bottles to consist of, on average, 50% recycled content by 2030.
- Danone[45] plans for evian® brand water bottles to be made using 100% recycled PET by 2025.
- Unilever[46] aims for at least 25% of its plastic packaging to be made from recycled materials by 2025.

Design for recycling

- Unilever[47] has internal guidelines on design for recyclability of plastic products, with strategies like modular packaging, refills, design for disassembly and reassembly, and use of recyclable materials.
- Method[48] designs its product packaging for maximum recyclability, using primarily the widely recycled plastics #1 and #2. Its 1-PET plastic bottles contain 100% post-consumer content.
- Nestlé[49] has identified hard-to-recycle materials, such as polyvinyl chloride (PVC) and polystyrene (PS), and plans to phase out the use of these materials in its packaging.

Life cycle evaluation

- BASF[50, 51] has conducted eco-efficiency analyses on hundreds of its products, including its ecovio® polymer, to determine their life cycle impacts.
- NatureWorks[52] participated in a life cycle assessment conducted by an independent third party to determine the sustainability of the company's Ingeo™ polymers.
- Nespresso[53] commissioned a life cycle assessment by Quantis to determine the environmental impact of several espresso capsule options.

The Ideal

- Continued growth in each of these practices for more technologies and products.
- Increased use of recycled content creating demand for recycled feedstock and supporting recycling.
- No more use of non-recyclable polymers.
- Wide-scale adoption of global harmonized design standards for products and packaging.

Process optimization

Closed loop production

- Aquafil[54] engineers ECONYL® Pure, a fiber that can be infinitely repurposed and is made of 100% regenerated nylon and at least 50% post-consumer waste.
- EFS Plastics[55] reprocesses curbside-collected household mixed plastics waste into reprocessed resins, diverting 60 million pounds of waste from landfills each year.

- Ioniqa and Indorama[56] are partnering with Unilever to test new technology that recycles waste PET into high-quality, food-grade packaging.

Energy efficiency

- Jabil[57] replaced its injection moulding presses at its North Carolina facility with electric models, reducing energy consumption by as much as 50%.

The Ideal

- Continued growth in closed-loop and energy efficient manufacturing processes.
- Widespread adoption of best practices to reduce leakage throughout the supply chain.
- Minimized secondary and tertiary packaging and use of reusable containers during transportation, storage, and distribution.

Responsible consumption and procurement

Content labelling

- Flustix[58] analyzes supply chains and labels products that it has certified to be plastic-free, contain reduced plastic content, or contain recycled plastic content.

Reduced single-use plastics

- Nestlé[59] is reducing single-use plastics by introducing water dispensers for refilling bottles, partnering in TerraCycle's Loop service to implement reusable packaging, eliminating plastic drinking straws, and eliminating unrecyclable single-use plastic products from all its facilities worldwide.

- Sobeys[60 CDN] announced it would remove plastic grocery bags from all 255 of its Canadian locations by the end of January 2020, eliminating 225 million plastic bags from circulation.

- Starbucks[61] announced it would eliminate or replace single-use plastic straws at all its stores by 2020, and has piloted a straw-less beverage cup lid.

- Unilever[62] is investing in refillable and reusable packaging, such as in its pilot for a laundry detergent dispensing machine, and investigating the potential for alternative materials, like paper and aluminum to replace single-use plastic packaging.

Reduced packaging

- McDonald's[63] collaborated with HAVI Global Solutions, its packaging supplier, to replaced PET with Clarified Polypropylene (CPP) in its coffee cups, reducing material use by 20%.

- Nestlé[64] has reduced plastics packaging use in its production processes by over 118 000 tonnes since 2015 through design optimization.

- Unilever[65] decreased the weight-per-consumer of its packaging by 18% between 2010 and 2018 by eliminating unnecessary packaging, optimizing design and materials, and concentrating products.

Sustainable purchasing

- The City of Windsor[66] has implemented city-wide standards as to how citizens and businesses can reduce the purchasing of plastics that cannot be recycled by the municipality.

The Ideal

- Ambitious targets to replace single-use plastics with reusable, recyclable, and biodegradable items.
- Global recycling labelling standards facilitates proper household waste sorting.

Specific Examples: Objective 2, Intensified Product Use

Sharing economy

Innovation hubs

- The Plastic Waste Innovation Hub[67] is a multidisciplinary team of scientists, engineers, designers, and social scientists developing design strategies to eliminate plastic waste.
- Think Beyond Plastic[68] offers an innovation centre, innovation hubs, a foundation, and startup support to foster entrepreneurship in the plastics circular economy, with a focus on packaging, bio-benign materials, and sustainable chemistry.

The Ideal

- Continued growth in platforms and hubs that connect multi-disciplinary teams to develop new practices and technologies and grow demand for recycled materials.

Short-term renting

Reusable packaging services

- TerraCycle[69] offers Loop, a product delivery system that partners with companies like Unilever, Procter & Gamble, and Nestlé to deliver products in reusable packaging, eliminating packaging waste.
- Plan B From Outer Space Oy[70] runs RePack, a reusable packaging service whose packaging can be returned by postbox and is durable for at least 20 cycles. Users receive a redeemable voucher after making a return.

The Ideal

- Large-scale adoption of reusable packaging by industry and consumers, without increasing negative impacts due to transportation and handling.

Specific Examples: Objective 3, Extending Life of Products and Components

Maintenance and repair

Durable goods recycling

- MBA Polymers[71] recovers pure plastics from durable goods, such as computers, electronics, and appliances, for use in many applications, including consumer products.

Self-healing plastics

- University of Illinois[72] researchers invented a polyurea polymer, widely used in plastics and other goods, that self-heals at room temperature in a low-cost, scalable process.

The Ideal

- Improved design to allow more recovery and recycling of plastic material in durable goods like appliances and electronics.
- Develop new technologies that ensure durability in use while still allowing for recycling or biodegradability after use.

Donating and reselling

Materials matchmaking platforms

- Excess Materials Exchange[73] is an online facilitated marketplace that matches excess materials and products with their highest-value reuse opportunity.
- The United States Business Council for Sustainable Development[74,75] operates Materials Marketplace, a platform that connects recyclers, manufacturers, and entrepreneurs, while also matching industrial waste streams with new business opportunities.

The Ideal

- Many opportunities to connect plastic waste with new uses through matchmaking mechanisms, with widespread uptake from large and small producers.

Refurbishing

Plastics welding and repair

- First Place Plastics Welding[76] CDN welds and repairs all types of thermoplastics from residential, commercial, industrial, and agricultural sources.
- The Plastic Surgeon[77] CDN welds and repairs plastic goods and components ranging from auto parts and household goods to industrial and agricultural machinery.

The Ideal

- Increased repair and reuse of plastic-containing products, such as appliances, auto components, textiles, and construction.
- Durable plastic goods can be repaired with relative ease.

Performance economy

None found

Specific Examples: Objective 4, Giving Resources New Life

Industrial ecology

Reduced Supply Chain Leakage

- The Port of Antwerp[78] and local plastics producers and distributers signed the Operation Clean Sweep® pledge, which targets zero plastics pellet loss during each step of production, handling, and transport.

Vertical integration

- Canada Fibers[79] CDN introduced an affiliate company, Urban Resource Group, to build local end markets and to help customers find value from waste. Its Urban Polymers division manufactures PET, PE, and PP from post-consumer and post-industrial plastics.
- IKEA[80] acquired a minority stake in Morssinkhof Rymoplast Group, a Dutch plastics recycling company, to increase long-term supply of recycled plastics.
- Imerys[81] integrated recycled content into its supply of additives for the plastic industry by acquiring ImerPlast UK (formerly REGAIN Polymers), a recycled polyolefin producer.

Distributed recycling models

- Banyan Nation[82] integrates thousands of informal, last mile recycling collectors using mobile, cloud, and IoT technology to recycle post-consumer and post-industrial plastic waste. It specializes in producing recycled resins for use in packaging, auto components, durable goods, and consumer electronics.
- Sierra Energy[83] produces recycling systems that can be used by municipalities, hospitals, campuses, and other institutions to convert most forms of waste, including municipal solid waste and industrial waste, into syngas.
- Renewlogy[84] developed commercial systems for recycling low-value, post-consumer waste into fuels. The systems can be installed on-site to eliminate costs of waste transportation, and can process 10 tons of plastic waste per day.

The Ideal

- Manufacturers downstream and upstream along the supply chain use each other's waste products as resource inputs.
- Distributed recycling infrastructure allows waste to be transported from the small-scale (municipalities, institutions, and households) to the large-scale (manufacturers and global supply chains).

Recycling and composting

Alternative Recycling Technologies

- Carbios[85] uses enzymes to depolymerize plastic waste into its original monomers in an infinite biological recycling process that results in high-quality materials.
- GreenMantra Technologies[86] developed a patented process to produce synthetic polymers and additives for industrial applications, like asphalt roofing and asphalt roads, by recycling post-consumer and post-industrial plastics.
- perPETual[87] invented a lower-temperature process to break down used PET bottles, without the addition of foreign chemicals, for re-use in PET-based products.
- ReNew ELP[88] developed Cat-HTR™ (Catalytic Hydrothermal Reactor), a platform that can convert mixed-waste plastics, including mixed composite polymers, multi-layer flexible plastics, and plastics contaminated with organic matter, into high-grade chemicals and oils.

Technologies for hard-to-recycle materials

- Agilyx[89] accepts waste polystyrene, in all forms, from households and businesses to be converted into monomers that are recycled back into polystyrene products.
- Polystyvert[90] CDN invented a low-temperature dissolution technology to recycle polystyrene into a finished product with the same properties as virgin-sourced polystyrene. The solvent used in the process is also recycled.
- Pyrowave[91] CDN recycles post-consumer polystyrene, including contaminated food containers, into high-quality products that can be used as alternatives to virgin-sourced plastics.
- Recycling Technologies[92] created RT7000, a modular and scalable machine that can be installed at waste and recycling sites to convert hard-to-recycle plastic waste into Plaxx®, a hydrocarbon product.

Biodegradable or Compostable Packaging

- Ethique[93] produces concentrated, solid bars of skincare and haircare products wrapped in compostable, plastic-free packaging, eliminating the need for plastic bottles and dispensers.
- Good Natured[94] CDN manufactures renewably-sourced, plant-based food packaging, bioplastic rollstock sheets, and organizational products for home and business following the ASTM D6400 composting standard that requires breakdown within 180 days in a commercial compost facility.

- Parkside[95] produces Park2Nature™, a compostable flexible packaging derived from natural sources that can be used to replace non-recyclable multi-layer packaging.

Biodegradable or compostable plastic goods

- BASF[96 97] produces a certified compostable polymer, ecovio®, containing bio-based content, for use in a variety of applications from organic waste bags to agricultural films. BASF's ecoflex® polymer is biodegradable and certified compostable.
- Biome[98] develops 100% biodegradable and compostable plastics according to EN 13432, ASTM D6400 and Vinçotte OK standards.
- Mitsubishi Chemical[99,100] produces BioPBS™ plastic, derived from renewable resources like sugarcane, cassava, and corn. BioPBS™ can be composted in 30°C soil in open-air landfills. Mitsubishi Chemical's bio-based plastic DURABIO™ is derived primarily from plant-based isosorbide.

Tolling and grinding services

- EPL Plastics[101] reprocesses manufacturers' plastic waste scraps for use in finished products, with a pickup and delivery option that returns reprocessed material to the original facility.
- Waste-Not Recycling[102] purchases scrap plastic in a wide variety of forms and reprocesses it into high-quality material for manufacturing.

Developing markets for recycled materials

- Loop Industries[103,104,105,106,107,108,109 CDN] has established supply chain agreements with Danone, PepsiCo, L'OCCITANE, Coca-Cola, offtake agreements with L'Oréal and Drinkworks, and a joint venture with Indorama to commercialize a sustainably-produced polyester resin.

The Ideal

- Continued growth in each of these practices.
- Scale-up of recyclable, reusable and/or compostable plastic products creates more demand for recycled plastic feedstock.
- Global recycling system archetypes allow for widespread design for recycling and recycling at economies of scale.
- Regions enter long-term contracts with recycling companies to encourage investment and innovation.

Energy recovery

Energy Recovery and Fuel Production From Plastic Waste

- Agile Process Chemicals[110] manufactures pyrolysis plants that convert plastic waste, including mixed plastics, plastic bags, and packaging, into pyrolysis oil and electricity at a 95% conversion rate.
- Agilyx[111] converts mixed plastic waste into light sweet synthetic crude oil, which refineries can use to produce fuel products like gasoline, diesel fuel, and jet fuel, in addition to new plastics.
- RES Polyflow[112] has developed an energy recovery system that can be used locally to convert mixed waste plastics into fuels and petrochemicals. Each vessel system can convert 60 tons of polymer waste per day.

The Ideal

- Plastic waste that cannot otherwise be reused, recycled, or composted is transformed into energy with minimal environmental impact.

5.4. Additional Resources

The following are additional resources that researchers, practitioners, and policymakers can draw on to further advance awareness and understanding of opportunities for circularity for Canada's plastics sector.

Selected Global Public Policies Supporting Plastics Circularity

- *The Ocean Plastics Charter :* A landmark agreement led by Canada, this global commitment to eradicate plastic pollution has been signed by 26 countries and 60 businesses and civil society organizations.[113]

- *The Canada-wide Strategy on Plastic Waste* : This strategy of the Canadian Council of Ministers of the Environment envisions zero plastic waste in Canada through a circular economy of plastics. The Canada-wide Action Plan on Zero Plastic Waste—Phase 1[114] introduces concrete, coordinated actions to implement the strategy, including a federal ban on harmful single-use plastics as early as 2021.[115] This will ban items such as plastic grocery bags, straws, stir sticks, six-pack rings for beer, cutlery, and foodware made from hard-to-recycle plastics. These bans are based on evidence that these items are found in the environment, are often not recycled, and have readily available alternatives.[116]

- *The New Plastics Economy initiative* : This initiative of the Ellen MacArthur Foundation unites hundreds of companies, cities, policymakers, academics, students, NGOs, and citizens to spark a global transition to a circular economy for plastics through strategies such as the New Plastics Economy Global Commitment. The Plastics Pact network connects initiatives and organizations globally, and is gaining momentum with various national and regional Pacts around the world, including the Canada Plastics Pact that launched in January 2021. [117,118]

- *Harmonized design standards for packaging :* WRAP,[119] RECOUP,[120] Association of Plastics Recyclers,[121] EBRP,[122] Plastics Recyclers Europe,[123] and the Consumer Goods Forum[124] each have harmonized standards to promote recyclability and circularity

Selected Documents on Circular Economy and Plastics Sector

Understanding the global plastics economy

World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company. (2016). *The New Plastics Economy — Rethinking the future of plastics*. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/EllenMacArthurFoundation_TheNewPlasticsEconomy_Pages.pdf

A comprehensive analysis of global plastic waste flows, this report establishes key findings and outlines a vision for a global circular economy of plastics. Based on literature review, expertise from over 40 companies and cities along the plastic waste chain, and consultations with academic experts and non-governmental organizations, the report determines the key findings and outlines a vision for achieving a circular economy of plastics through more effective after-use pathways for plastics; reduced leakage of plastics into natural systems; and decoupling plastics from fossil feedstocks. The report's recommendations led to the establishment of a new initiative by the Ellen MacArthur Foundation to foster collaboration between all stakeholders in the global plastics chain, from producers and manufacturers to cities and NGOs.

Understanding the Canadian plastics economy

Deloitte, Cheminfo Services Inc., & Environment and Climate Change Canada. (2019). *Economic Study of the Canadian Plastics Industry, Markets and Waste – Summary Report to Environment and Climate Change Canada* (Cat. No.: En4-366 /1-2019E-PDF). Retrieved from http://publications.gc.ca/collections/collection_2019/eccc/En4-366-1-2019-eng.pdf

Based on national statistics, industry documents and reports, and interviews with industry members, this report presents an overview of the plastics value chain in Canada, from raw material production to end-use in various sectors. It highlights 2030 scenarios for the value chain and presents an assessment of environmental, economic, and social impacts of these scenarios. The report recommends strategies and measures that include creating markets for recycled plastics, enhancing plastics collection, expanding value-recovery options, and extending plastics' lifetime to reduce and delay waste.

Smart Prosperity Institute. (2019). *A Vision for a Circular Economy for Plastics in Canada: The Benefits of Plastics Without the Waste and How We Get it Right*. Retrieved from https://web.archive.org/web/20191216053917/https://institute.smartprosperity.ca/sites/default/files/report-circulareconomy-february14-final.pdf

SPI inventoried the barriers to a plastics circular economy and the opportunities to overcome them. The report draws attention to the rate of plastic waste and points Canada towards an industrial policy that will fundamentally shift the production and use of plastics towards circularity. Although this process will not happen overnight, it will represent an evolution of the plastics industry in Canada, and the lessons learned could be applied to other Canadian economic sectors.

Canada's action plan for a circular economy of plastics

Canadian Council of Ministers of the Environment. (2019). *Canada-Wide Action Plan on Zero Plastic Waste – Phase 1*. Retrieved from https://www.ccme.ca/files/Resources/waste/plastics/1289_CCME%20Canada-wide%20Action%20Plan%20on%20Zero%20Plastic%20Waste_EN_June%2027-19.pdf

This report outlines the first phase in Canada's strategy to transition to a zero plastic waste economy in line with the Ocean Plastics Charter signed by Canada and other countries.-Phase 1 focuses on product design, single-use plastics, collection systems, and improving recycling capacity. A 2019 stakeholder workshop identified priority action areas, lists of actions for each area, and targeted completion dates. Phase 2, to be released in 2020, "will focus on preventing plastic pollution in marine ecosystems improved plastics pollution monitoring, increased consumer awareness, and a focus on global action.

Global initiatives for a circular economy of plastics

Ellen MacArthur Foundation. (2017). *The New Plastics Economy: Rethinking the Future of Plastics & Catalysing Action*. New Plastics Economy. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEC-Hybrid_English_22-11-17_Digital.pdf

Based on expert interviews and analysis of existing reports, this report presents three strategies to reduce plastic waste, building on the vision and roadmap for systemic change towards a circular economy of plastics that was established in the 2016 report *The New Plastics Economy — Rethinking the future of plastics*. While plastics are valuable materials whose use has greatly increased in the past half-century, their negative environmental impacts necessitate a new system. Highlighting statistics on global packaging use, this report sets out an action plan to reduce plastic packaging by 70% globally by 2050.

Ellen MacArthur Foundation & United Nations Environment Programme. (2019). *New Plastics Economy Global Commitment*. Retrieved from https://www.newplasticseconomy.org/assets/doc/GC-Report-June19.pdf

This report, developed in collaboration with the United Nations Environment Programme, how companies, governments, and other organizations are addressing plastic pollution under the New Plastics Economy Global Commitment, a pledge that brings together more than 400 organizations in a common vision to eliminate plastic waste. Over 200 businesses, representing 20% of all plastic packaging used around the world, as well as 16 governments and 200 other organizations have signed the commitment. The report profiles businesses, organizations, and governments that have signed the pledge, outlining their efforts to eliminate problematic or unnecessary plastic; transition from single-use models; implement reusable, recyclable, and compostable plastic packaging; and include post-consumer recycling content in packaging. A summary of this report is available on the Ellen MacArthur Foundation website.

WRAP UK. (2019). *Eliminating Problem Plastics*. Retrieved from https://www.wrap.org.uk/sites/files/wrap/Eliminating-problem-plastics-v2_0.pdf

This report outlines the efforts of members of the UK Plastics Pact, a coalition of businesses, to eliminate eight problematic plastics by 2020, where possible. It provides an overview of the eight problem plastics that members have committed to eliminate: disposable plastic cutlery, polystyrene packaging, cotton buds with plastic stems, plastic stirrers, plastic straws, oxo-biodegradable plastics, PVC packaging, and disposable plastic plates and bowls. The report identifies an additional 19 potentially problematic plastics to investigate further.

5.5. Conclusion to Plastics

This global scan of circular economy best practices in the plastics sector reveals that selected firms and operations are already implementing a wide range of practices that support circular economy objectives and strategies, whether or not these practices are explicitly identified as circular. However, there remains much that needs to be done. Currently, only 5% of the material value of packaging is retained after it has been used once, representing an approximate loss of C$107-160 billion dollars worldwide.[125] However, if the practices outlined above come into greater use, by 2050 up to 60% of plastic production could be based on reuse and recycling.[126]

In cataloging these examples, our intent is to demonstrate real-world strategies and practices that offer a starting point in the journey towards a circular economy. This information is offered as a background resource and reference source for future efforts to engage Canadian firms and innovators in the journey towards a circular economy, and – ideally – to begin building a Canadian plastics sector roadmap to a circular economy.

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